

STE Studies using AIRS Data



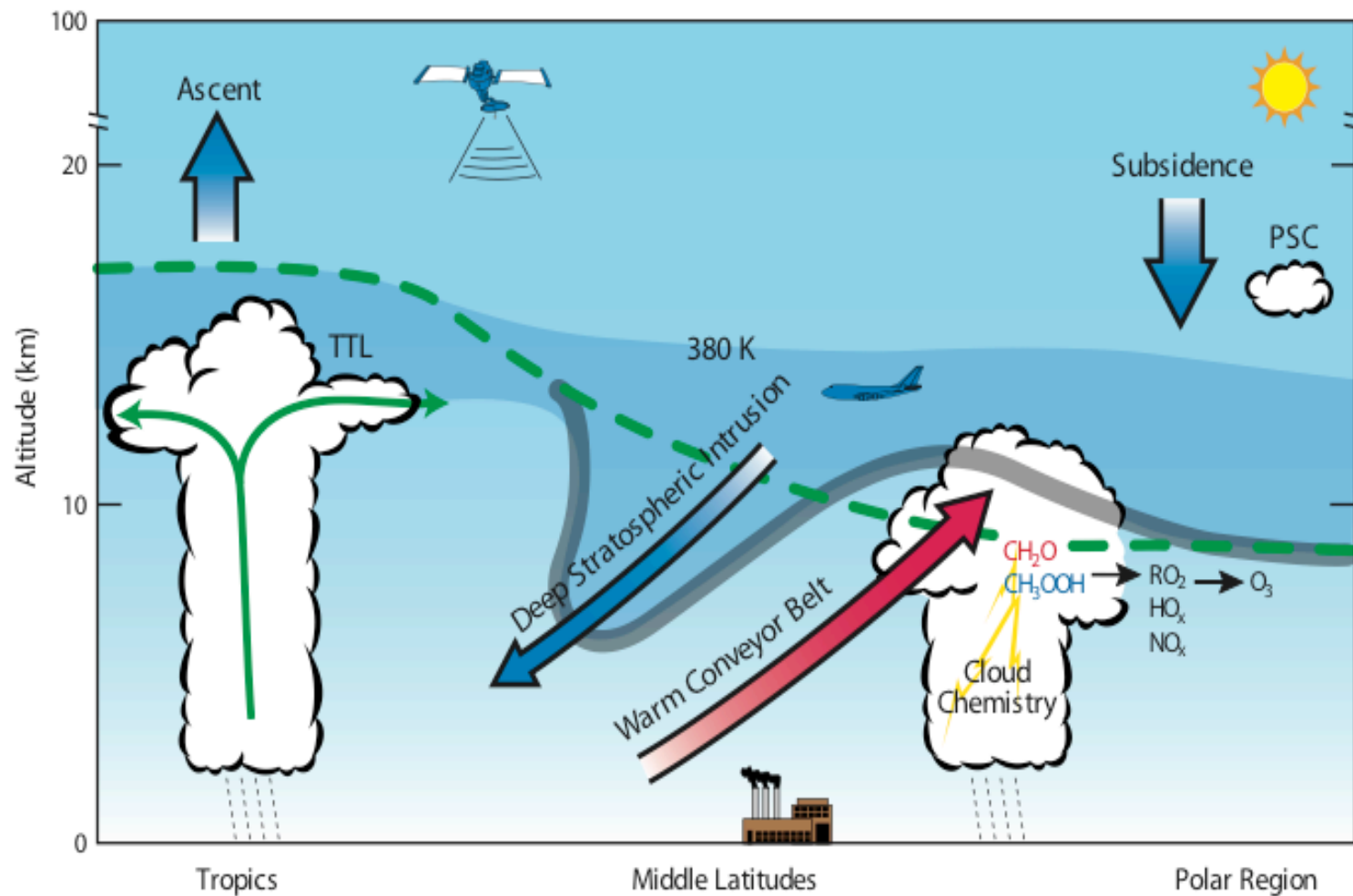
NCAR

Laura Pan, NCAR

Collaborators:

- **Andrew Gettelman and Bill Randel (NCAR)**
- **Chris Barnet and Jennifer Wei (NOAA, NESDIS)**
- **Bill Irion (JPL)**
- **Mel Shapiro (NOAA/NCAR)**
- **Ken Bowman (Texas A&M)**
- **Owen Cooper (NOAA/CMDL)**
- **Ed Browell (NASA/Langley)**
- **Rushan Gao (NOAA/AL)**
- **Hongbin Chen and Jianchun Bian (IAP/CAS, Beijing China)**
- **Greg Bodeker (NIWA, New Zealand)**
- **Kathleen Monahan and Adrian McDonald (Univ. Canterbury, New Zealand)**

Upper Troposphere & Lower Stratosphere – A region of coupled dynamics, chemistry and cloud microphysics



Scientific Motivations

Challenges of quantifying STE of chemical tracers (ozone, water vapor, and more)

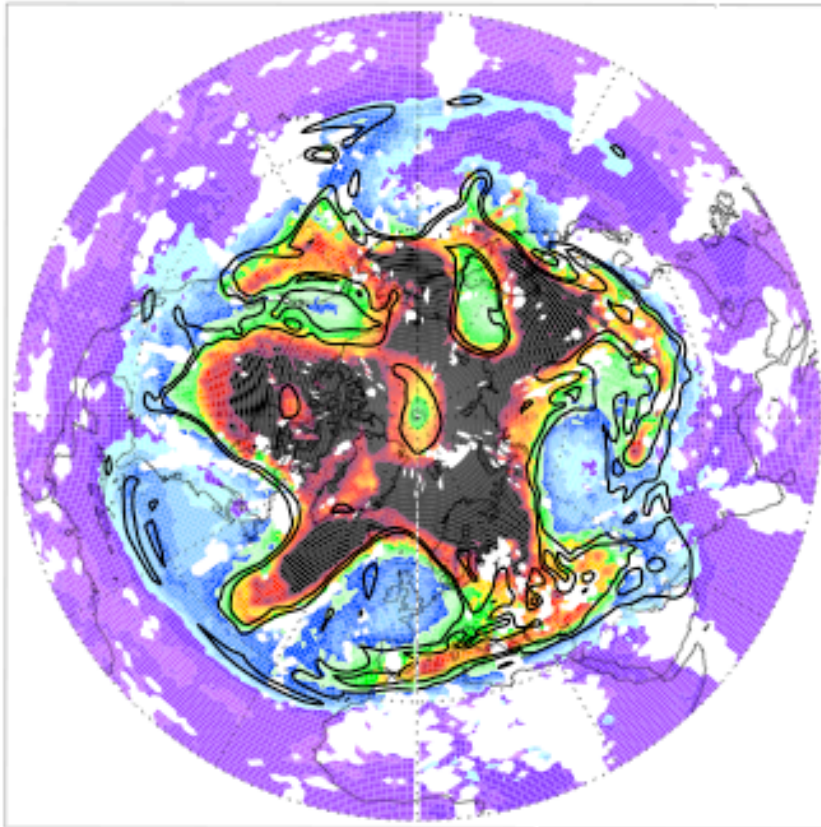
- When – seasonality,
- Where – preferred locations,
- How – the controlling processes,
- How much – e.g. how much does STE contribute to the UT ozone and LS water vapor?

Initial results

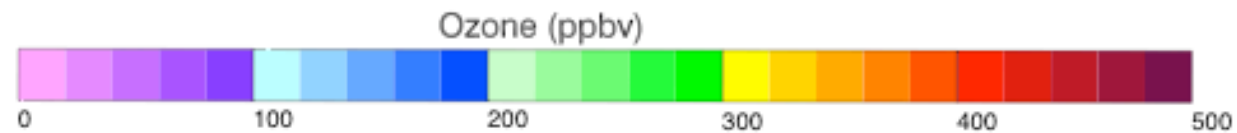
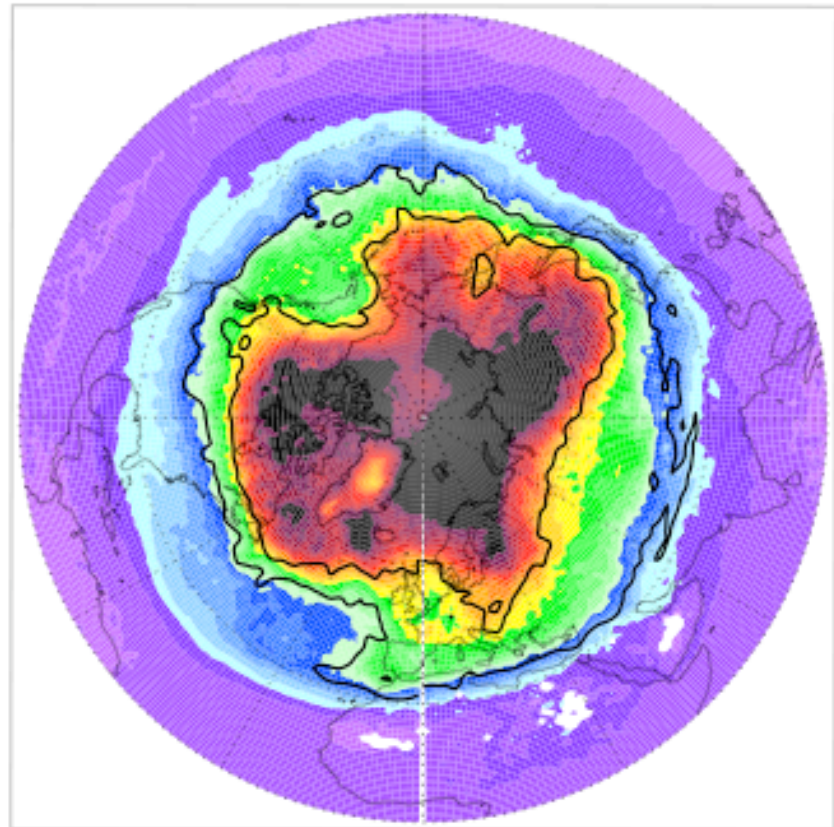
- Validation analyses of AIRS UTLS ozone
- Diagnosing STE using AIRS ozone and water vapor data

AIRS Ozone on 250 hPa (in 1x1 degree average)

May 15, 2004



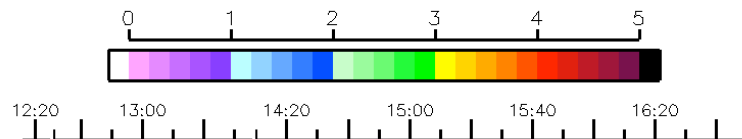
Monthly mean May, 2004



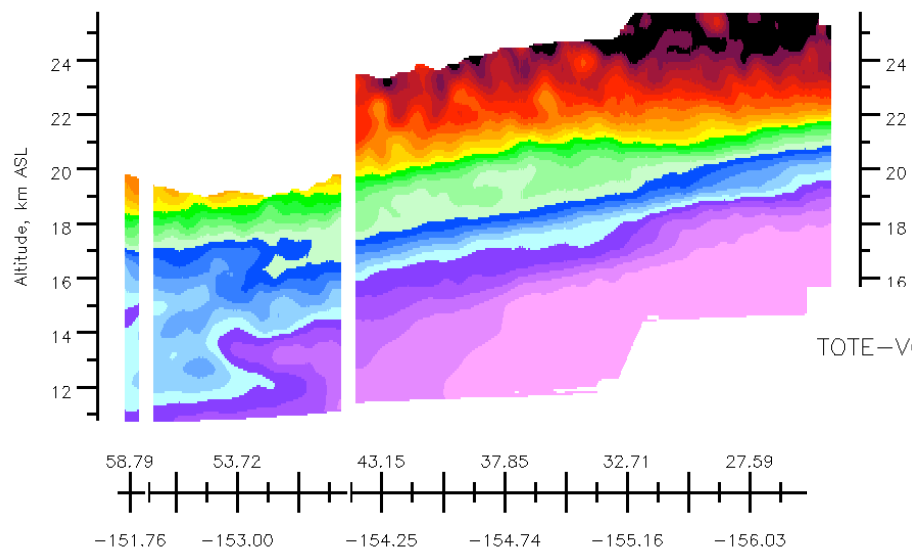
TOTE-VOTE

Fairbanks to Oahu
Flight 16
Ozone (ppmv)

8 Feb 96



UT

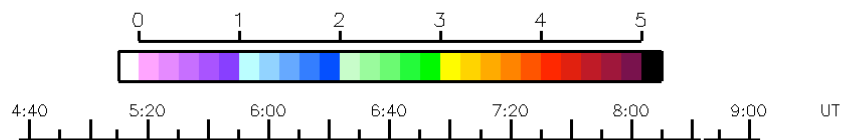


TOTE-VOTE

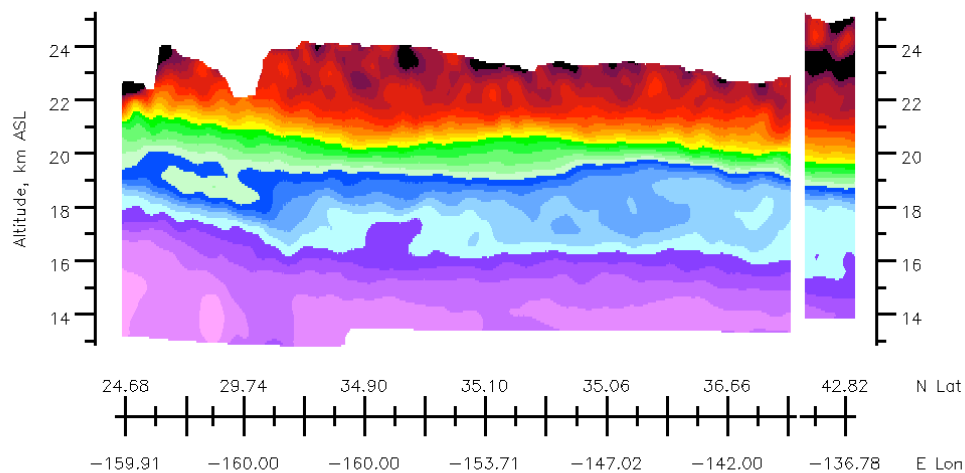
Before AIRS

Oahu to Ames
Flight 19
Ozone (ppmv)

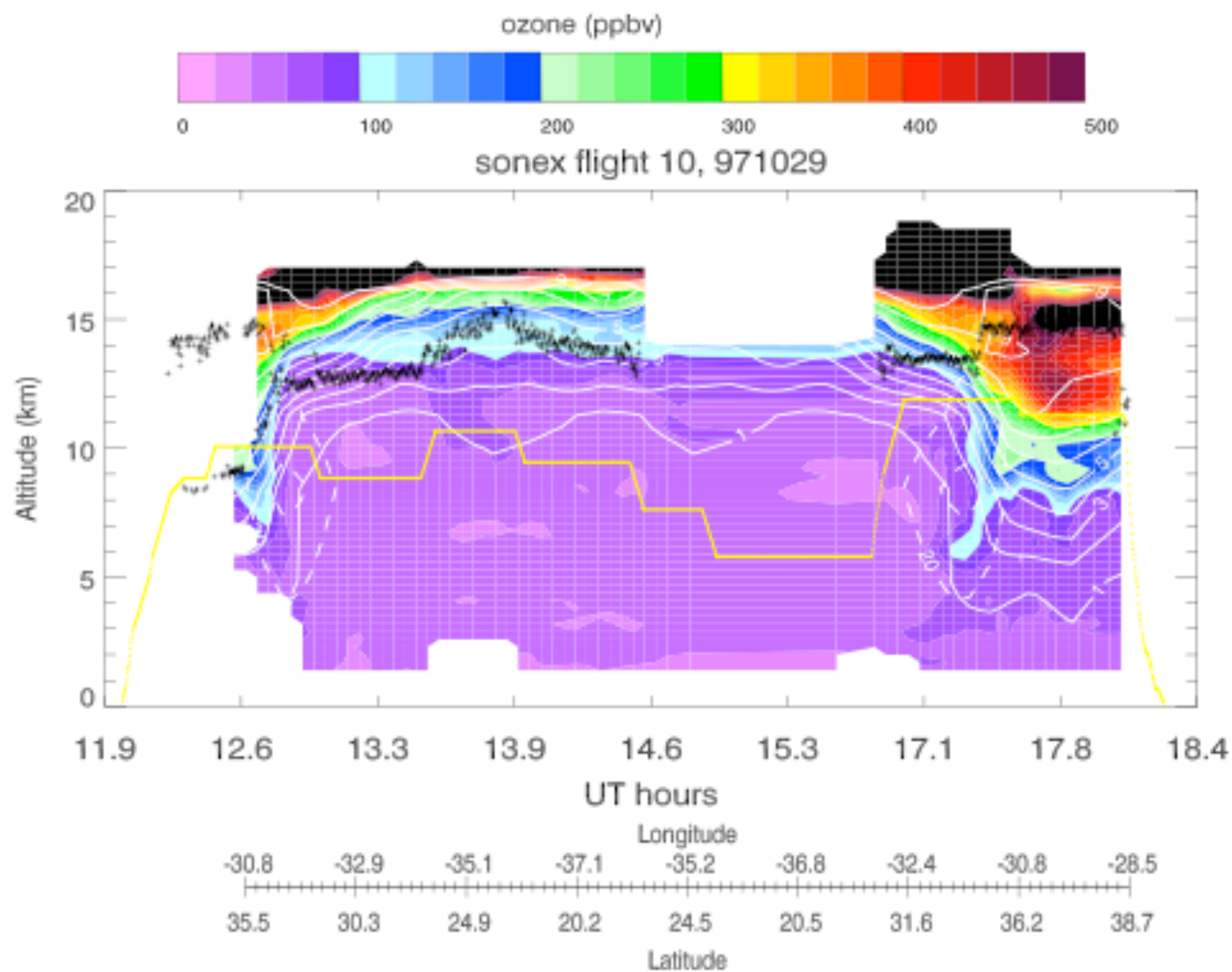
19 Feb 96



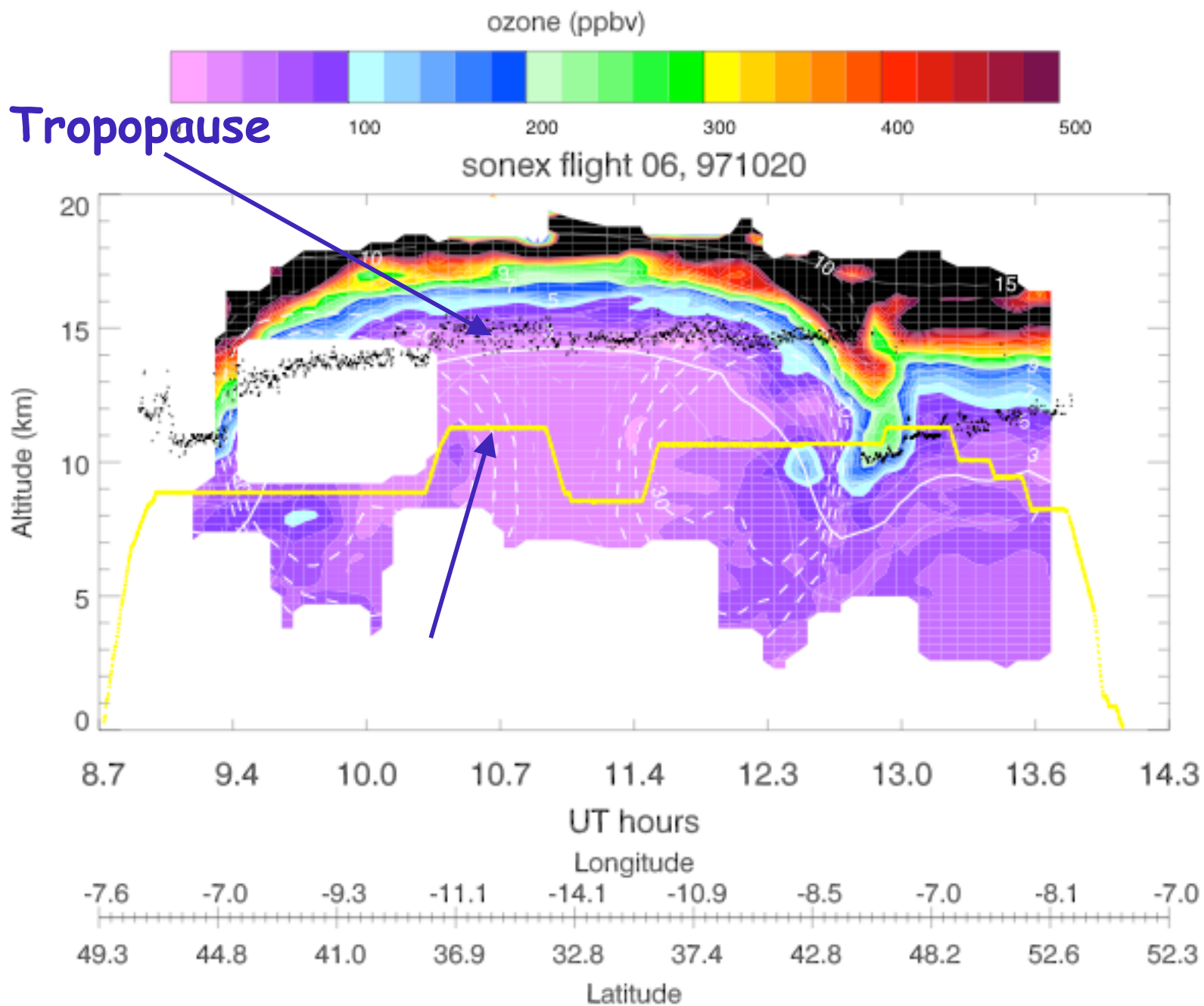
UT



NASA Langley DIAL (Ed Browell 's group)

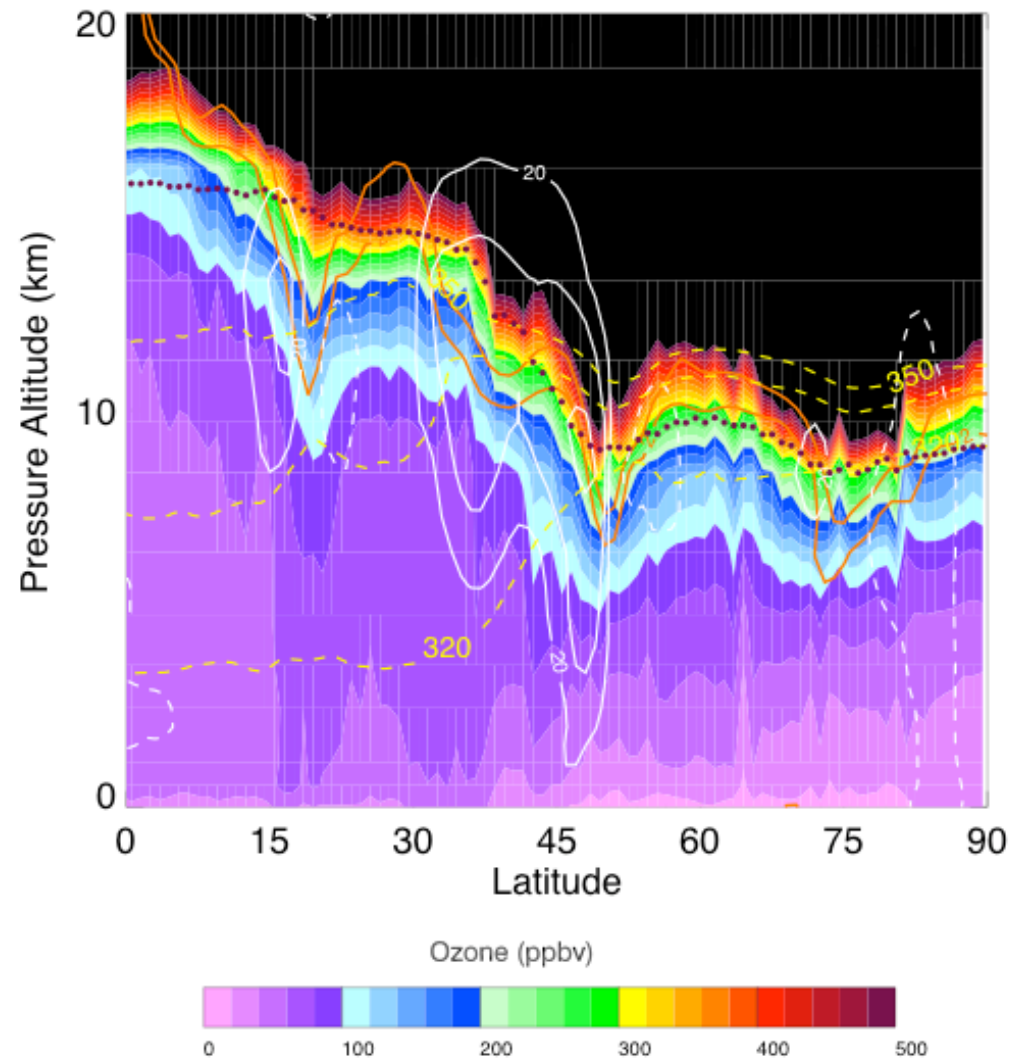


Tropopause



AIRS Ozone Cross Section (1x1 degree average)

May 15, 2004, Lon=160 E



Is AIRS ozone data meaningful, especially in the tropopause region?

Case studies using aircraft data:

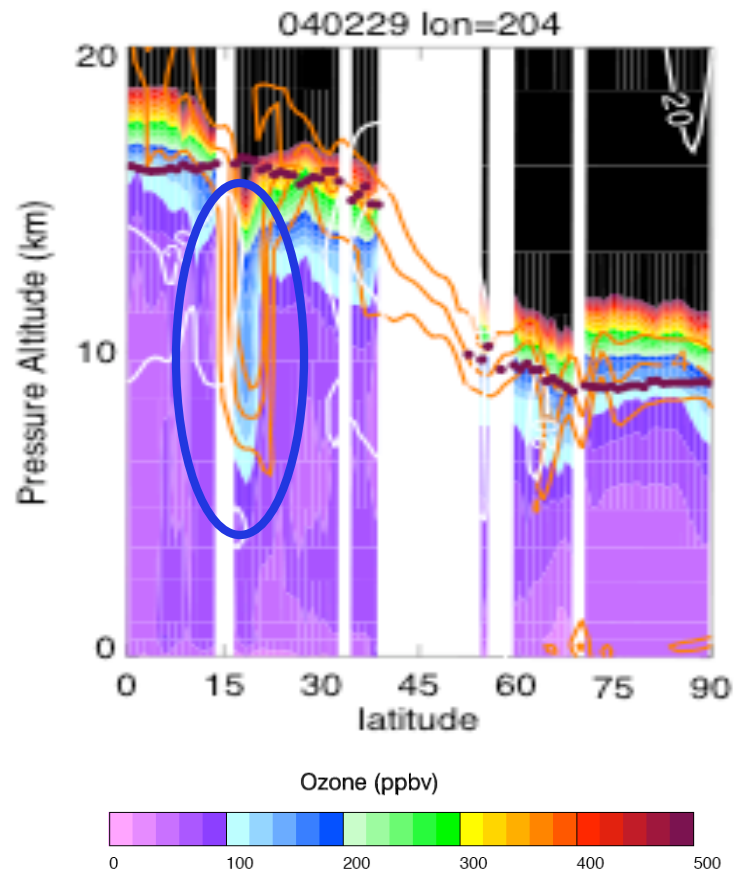
- In situ, NOAA G4 Hawaii, Feb 2004
- LIDAR NASA DC8 PAVE, Jan 2005
- In situ NASA WB57 AVE Houston, Nov 2004
- In situ NSF G5, START, Dec 2005

Statistical comparisons using ozonesondes

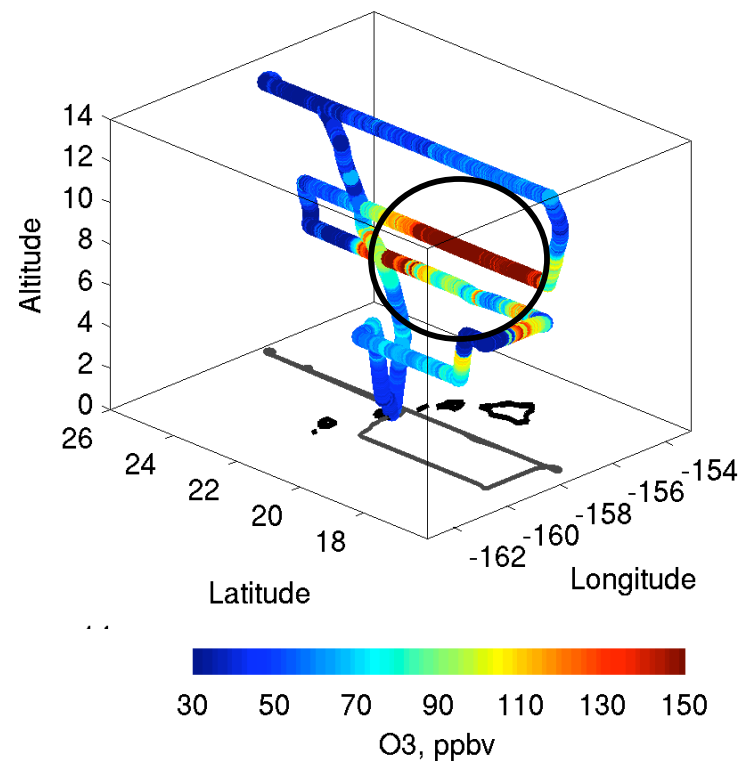
- Beijing, China
- Lauder, New Zealand

Case 1: NOAA G4, Hawaii Feb 2004

NH cross-sections Feb 29, 2004

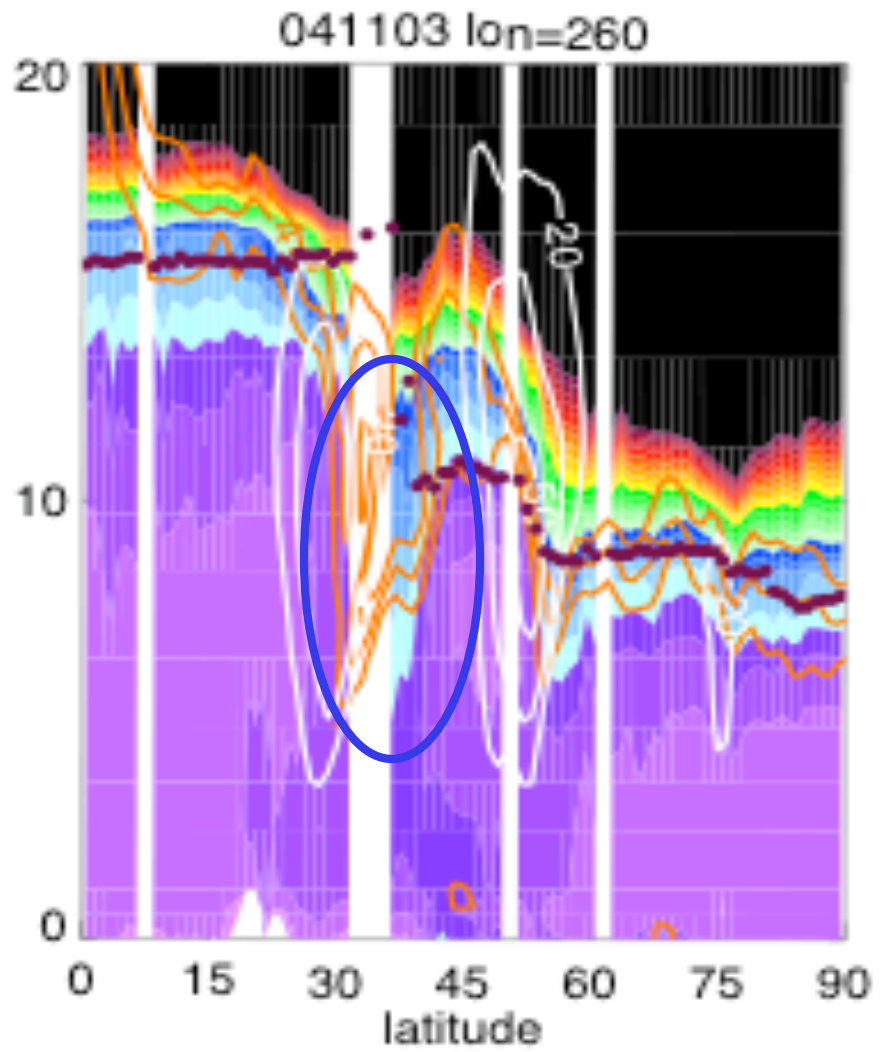
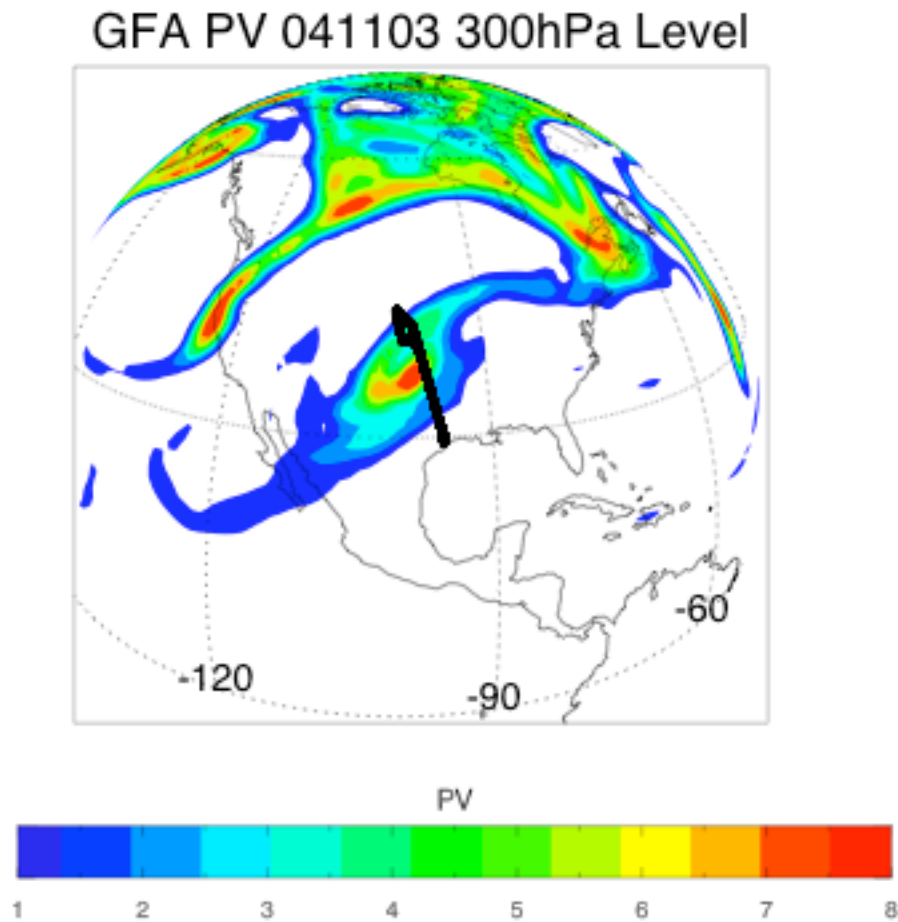


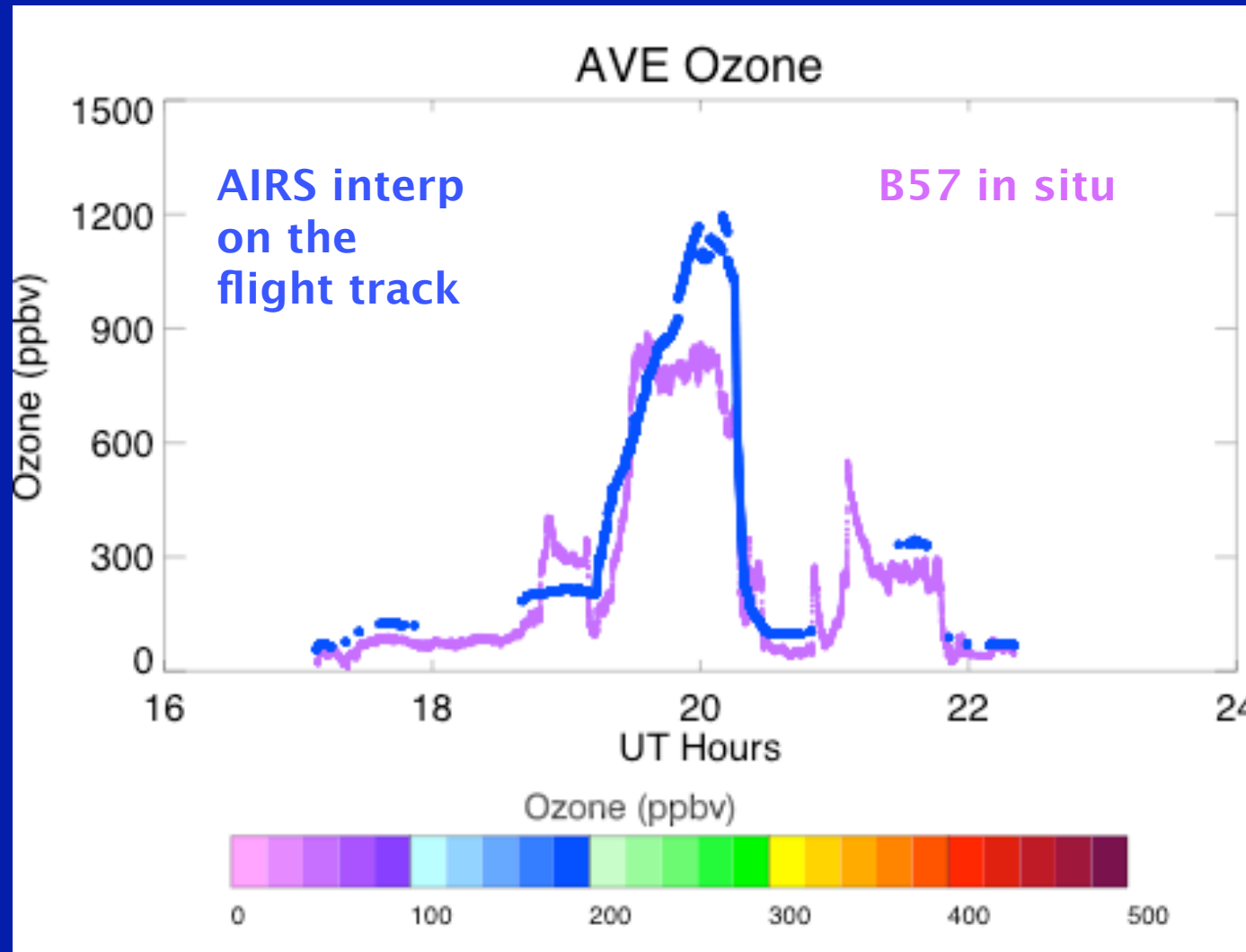
GIV measurements Feb 29, 2004



Cooper et al., [2005]

**Case 2: NASA WB57 AVE mission Houston, Nov 2004
(black line is the flight track, AIRS cross section on right)**

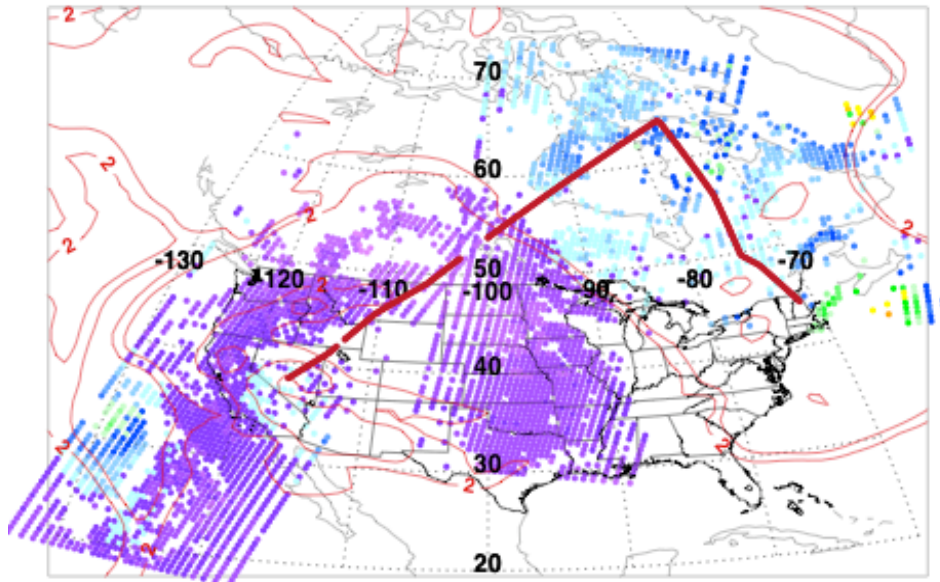




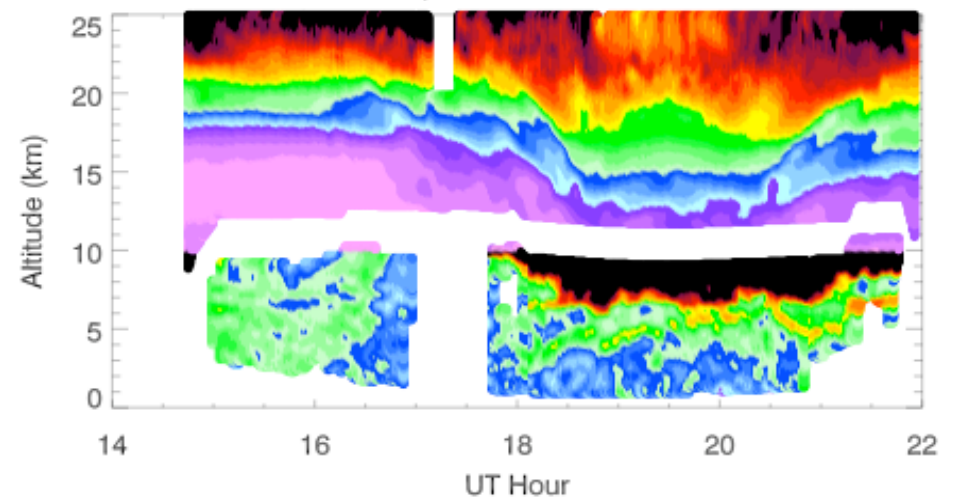
The agreement between AIRS and in situ between 50–500 ppb is remarkable

Case 3: NASA Langley DIAL, DC-8 PAVE Jan 2005

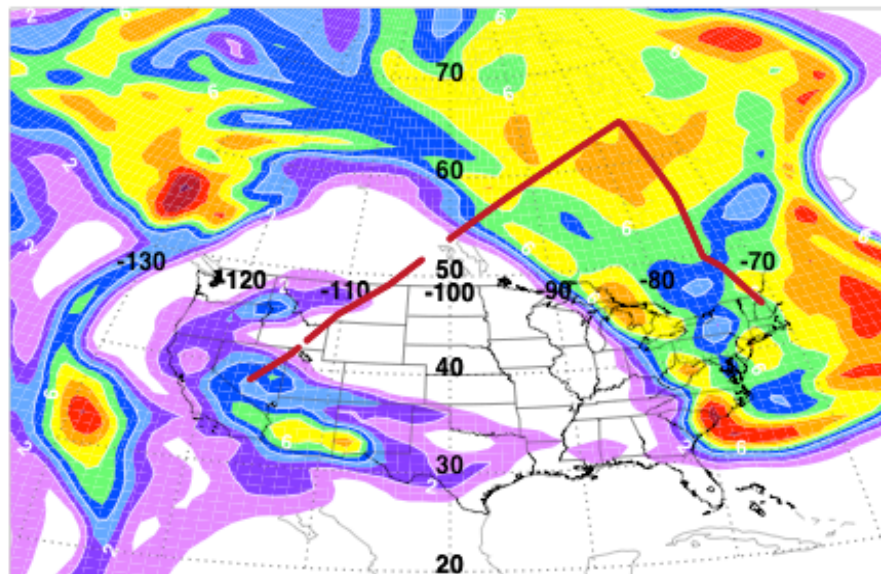
AIRS ozone 300 mb 2005-01-24



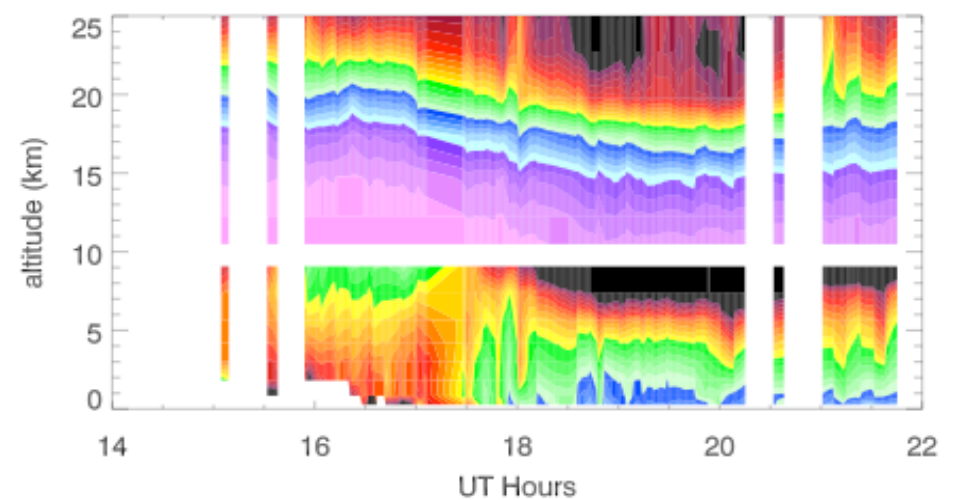
DIAL/PAVE 20050124



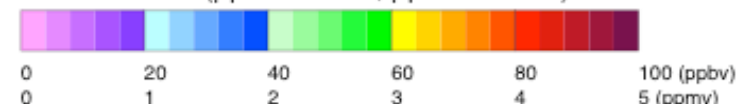
GFS PV 2005-01-24 12Z



AIRS ozone 050124



Ozone (ppbv <10km, ppmv >10km)



HIAPER Progressive Science Mission (22 November– 23 December, 2005)



DAYBREAK BEFORE TAKE OFF 2005-12-21

Stratosphere-Troposphere Analyses of Regional Transport (START) Experiment

Investigators:

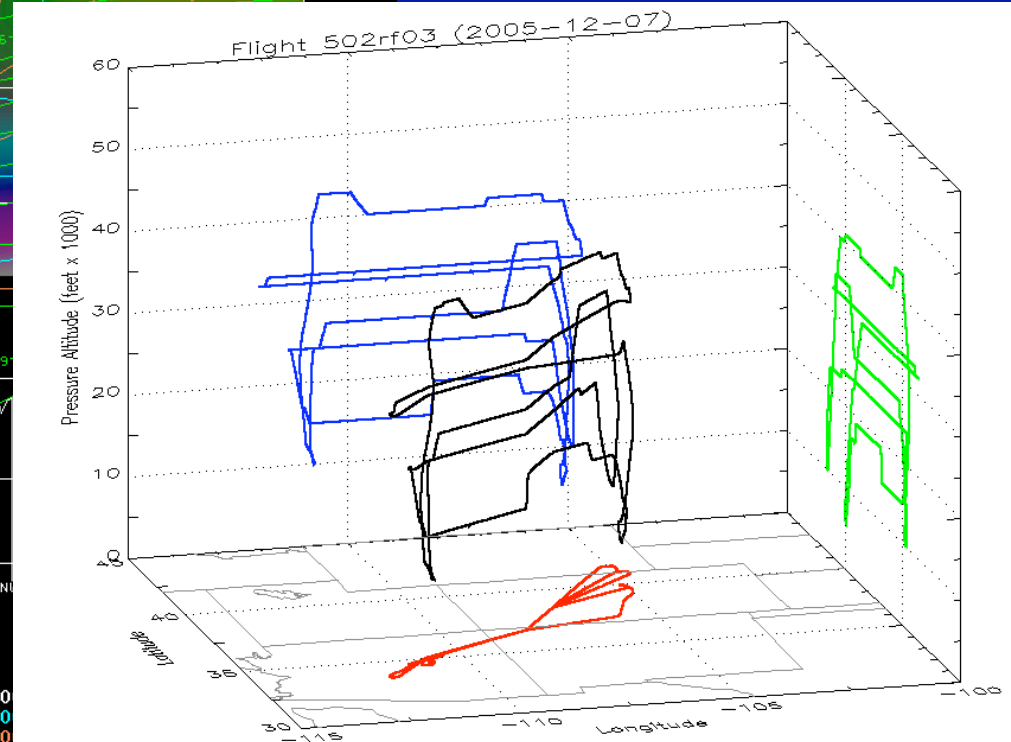
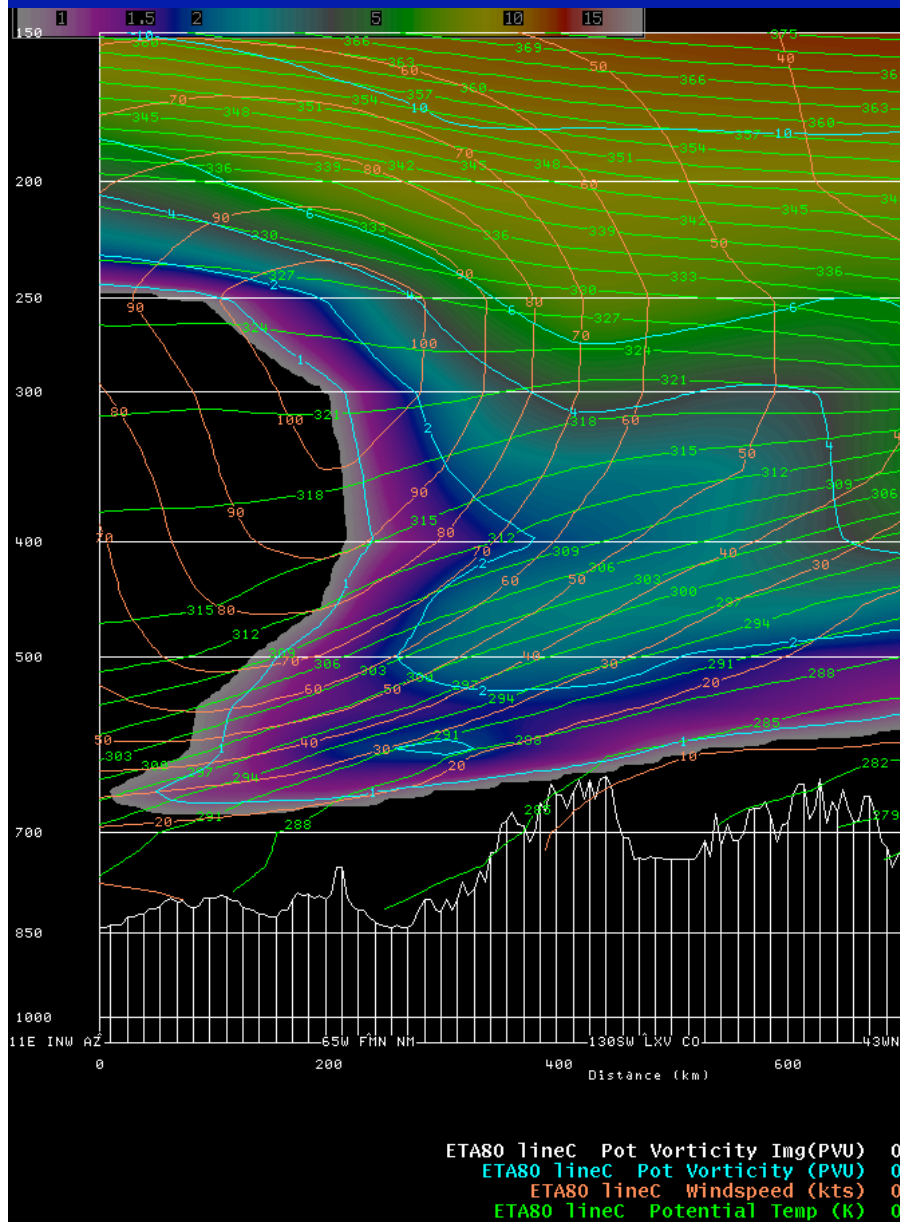
**Laura Pan (PI, ACD/TIIMES)
Ken Bowman (Texas A&M)
Mel Shapiro (NOAA/NCAR_{MMM})
Bill Randel (ACD)
Rushan Gao (NOAA)
Teresa Campos (ACD/EOL)
Chris Davis (MMM)
Sue Schauffler (ACD)**

Collaborators:

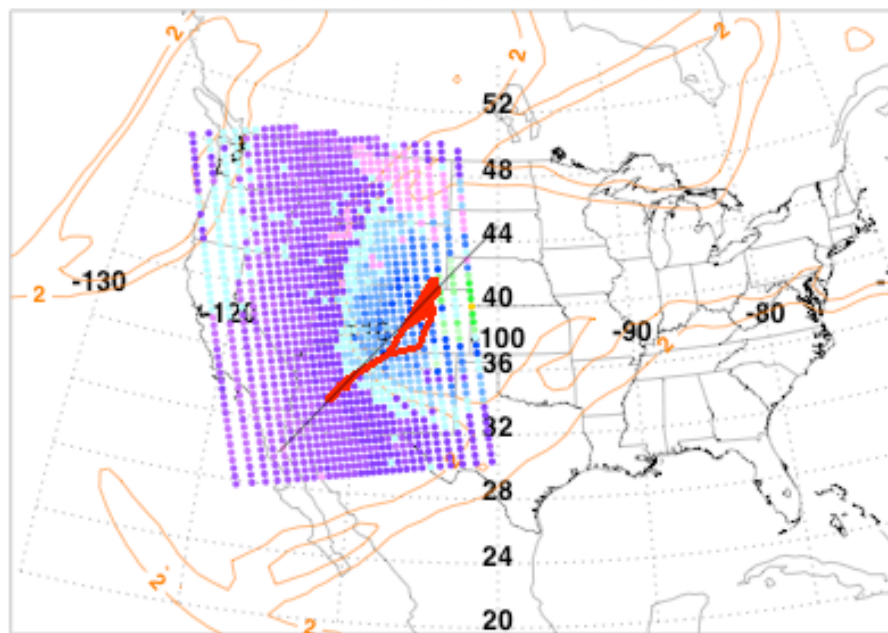
**Chris Barnet
Jennifer Wei
(NOAA/NESDIS
Satellite data)**

Case 4: START Flight 2 (2005-12-07)

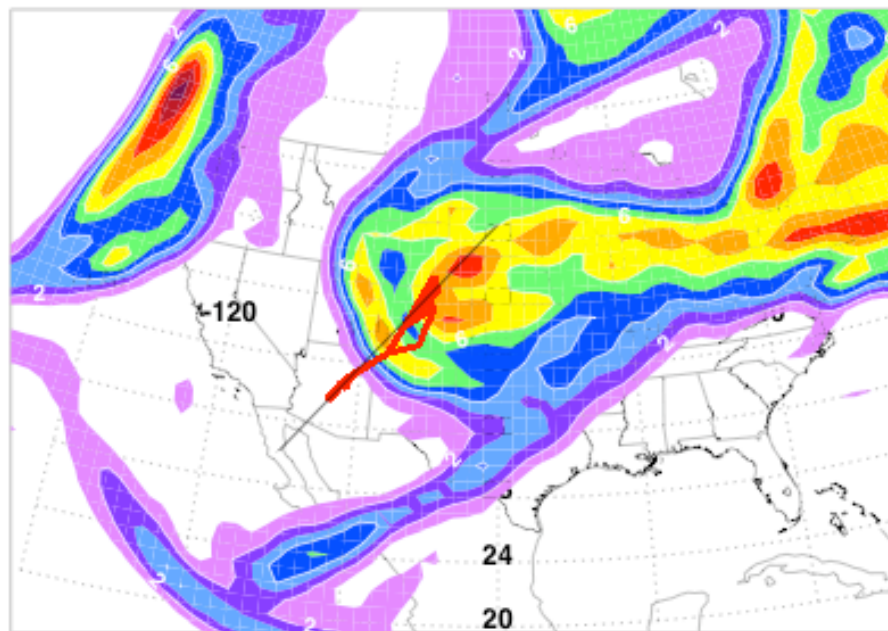
Hunt for Intrusion



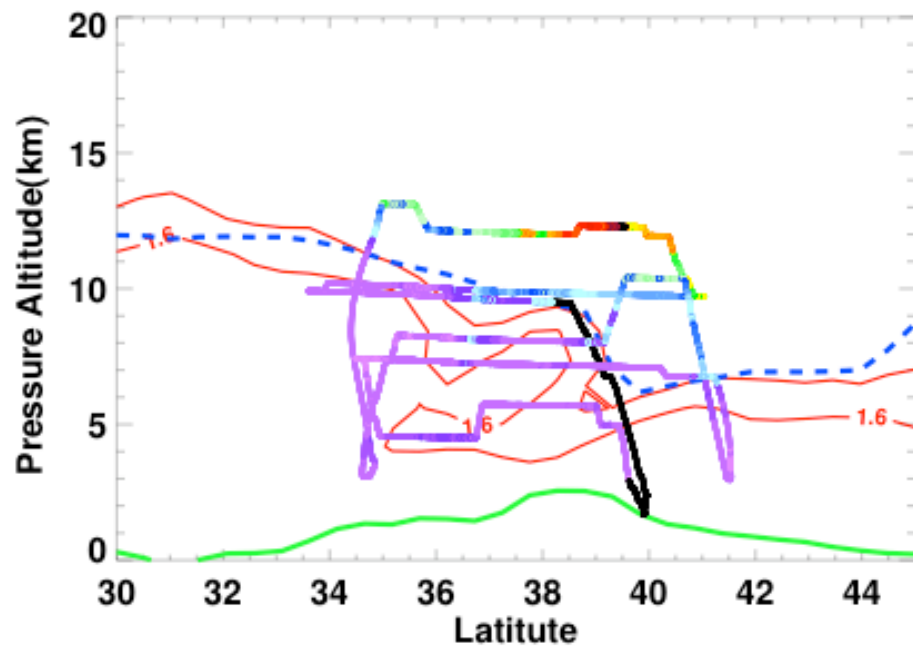
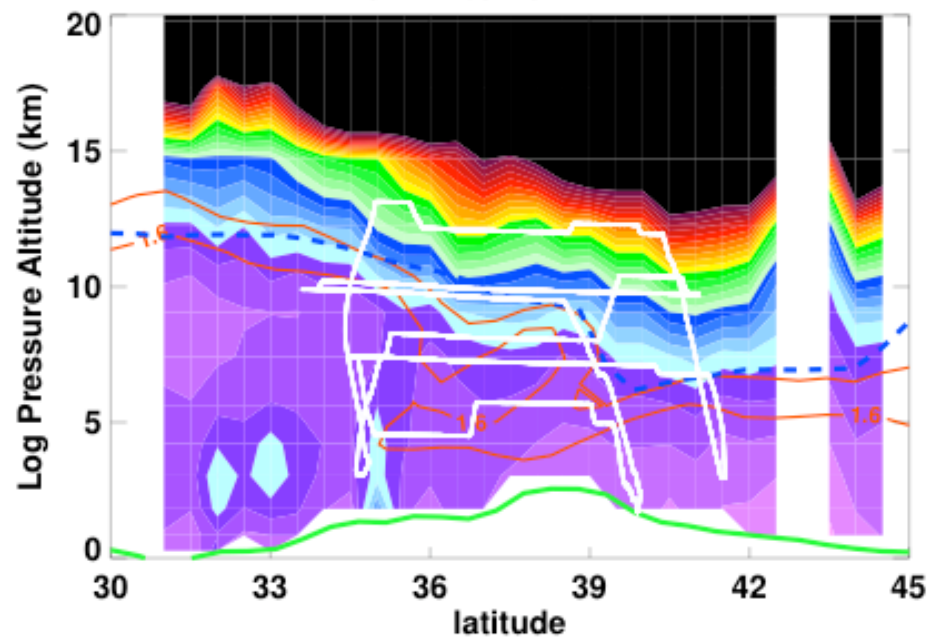
AIRS ozone 300-250 mb 2005-12-07

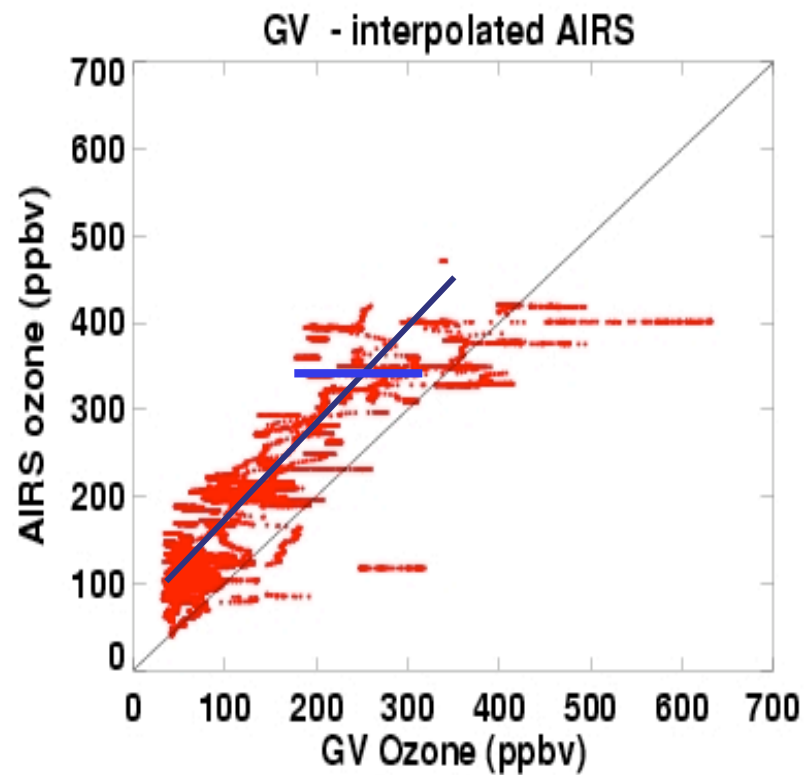
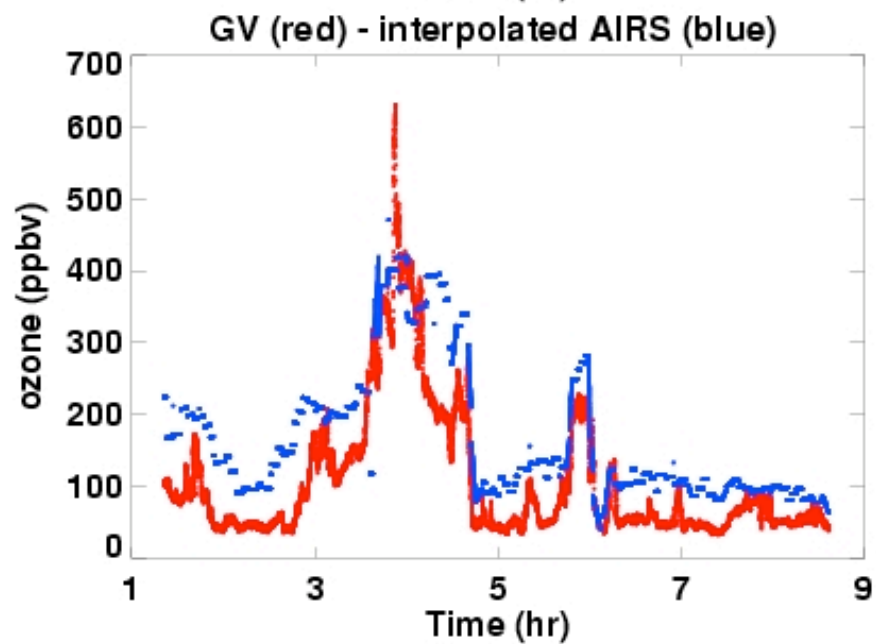
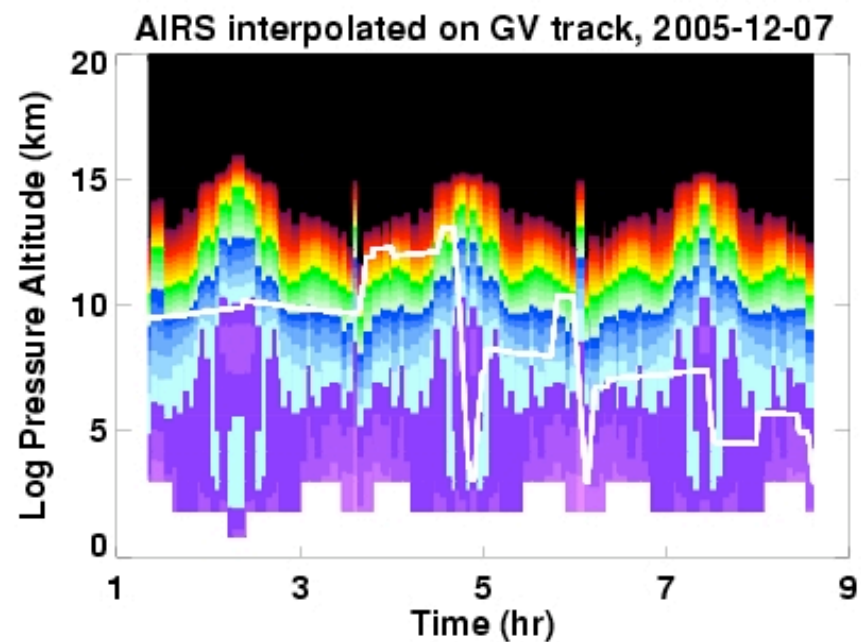


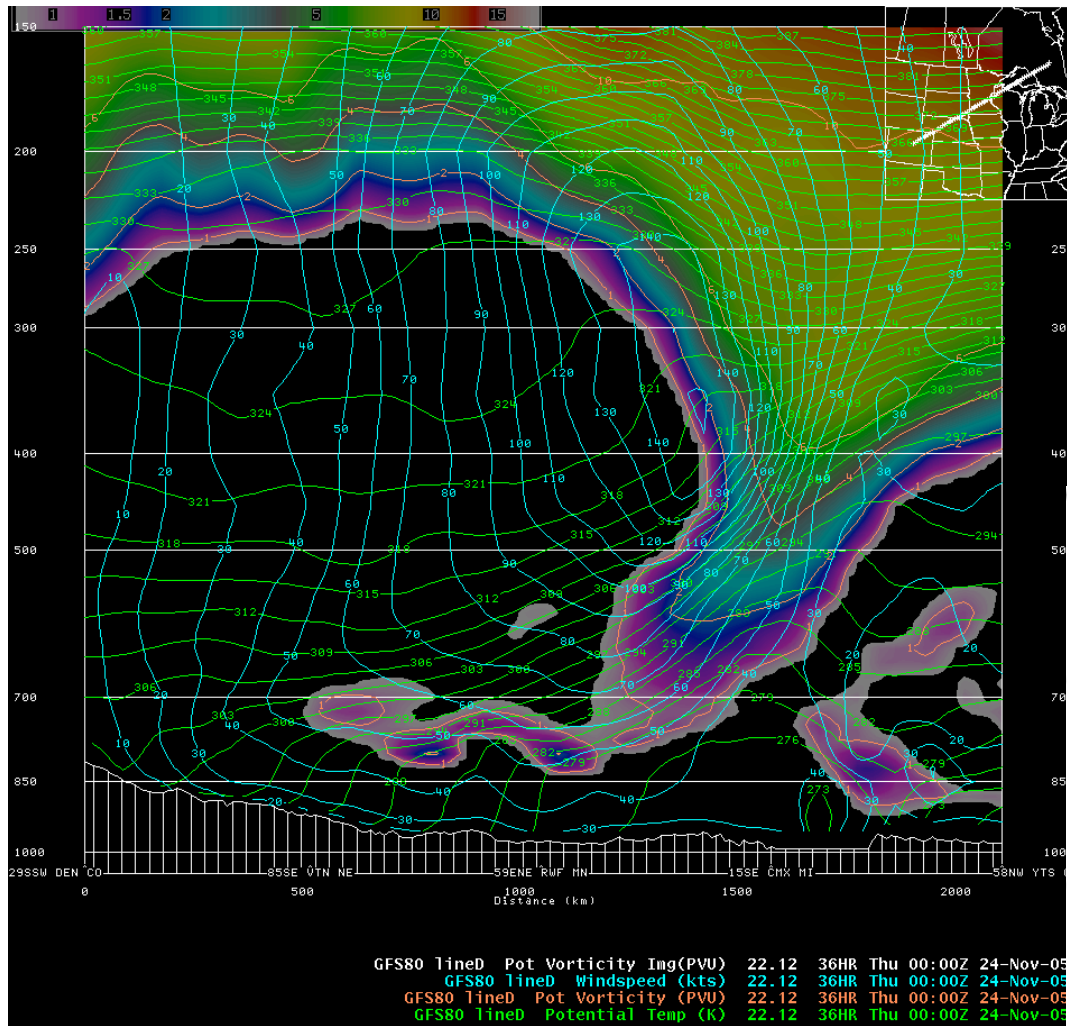
GFS PV 2005-12-07 18Z



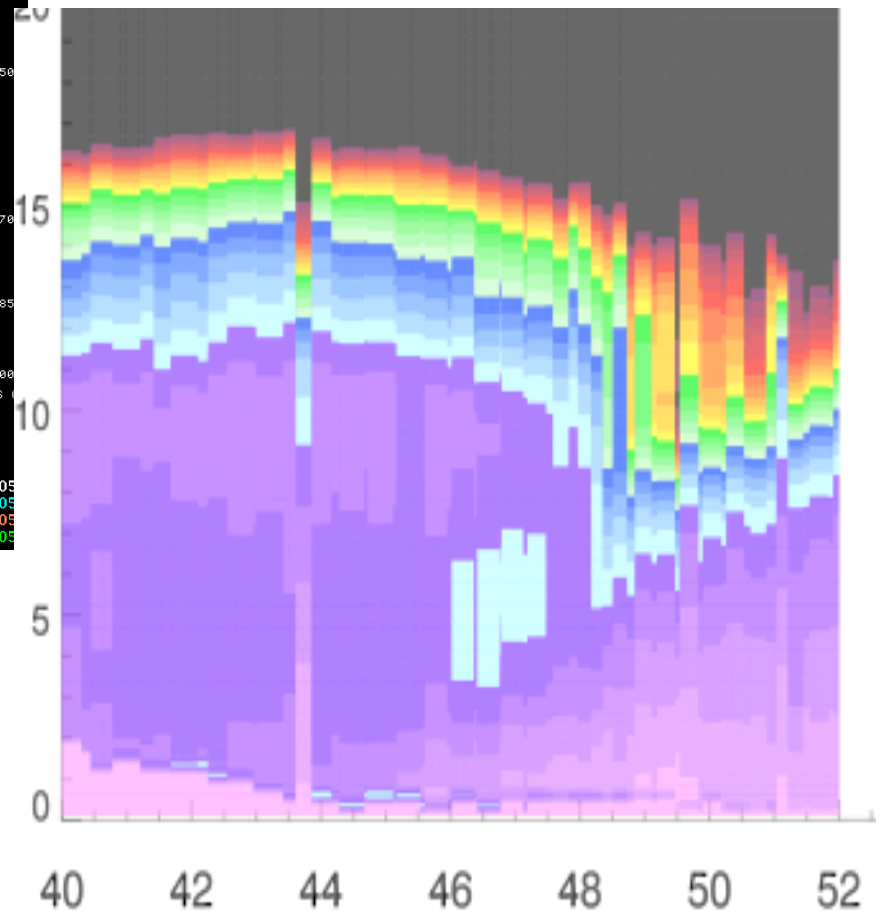
START 051207



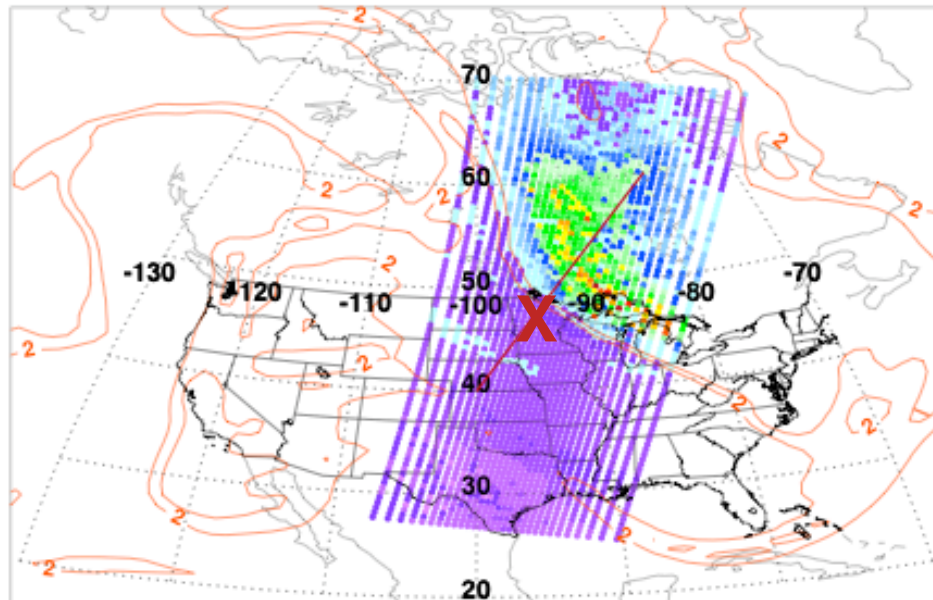




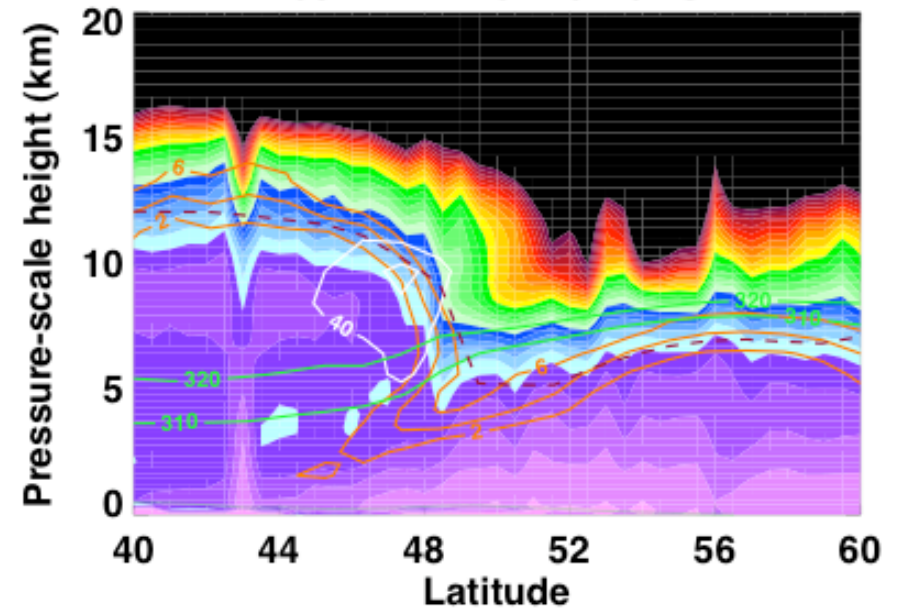
Planned 1st Flight Nov 23, 2005



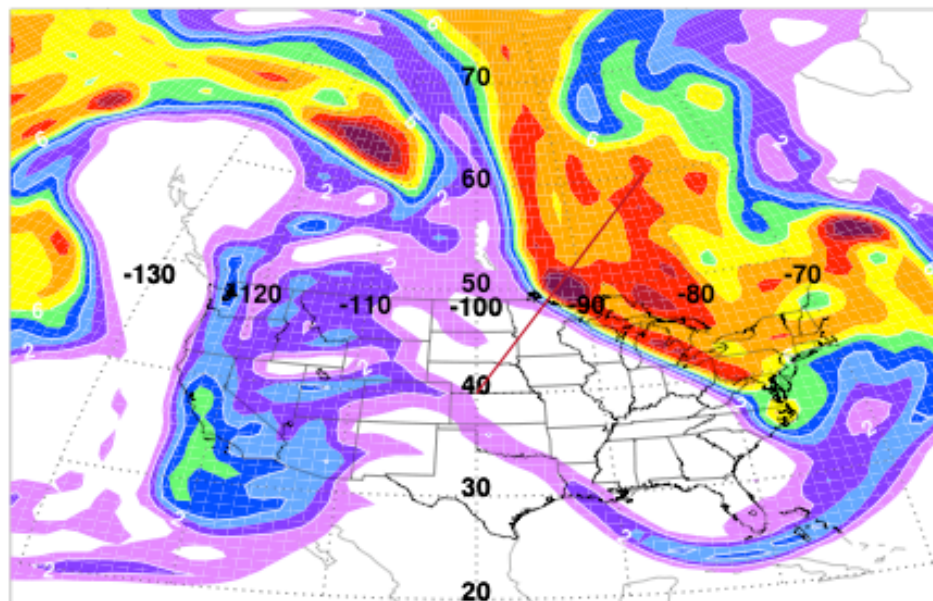
AIRS ozone 300-250 mb 2005-11-24



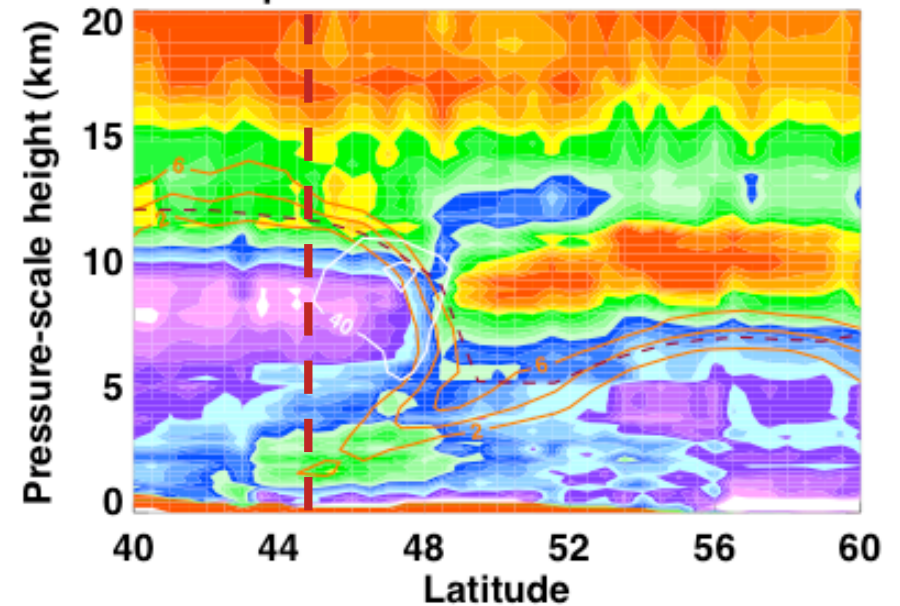
051124 Line A 6Z GFS



GFS PV 2005-11-24 6Z



PT Lapse rate 051124 Line A 6Z GFS



72659 ABR Aberdeen

100

200

300

400

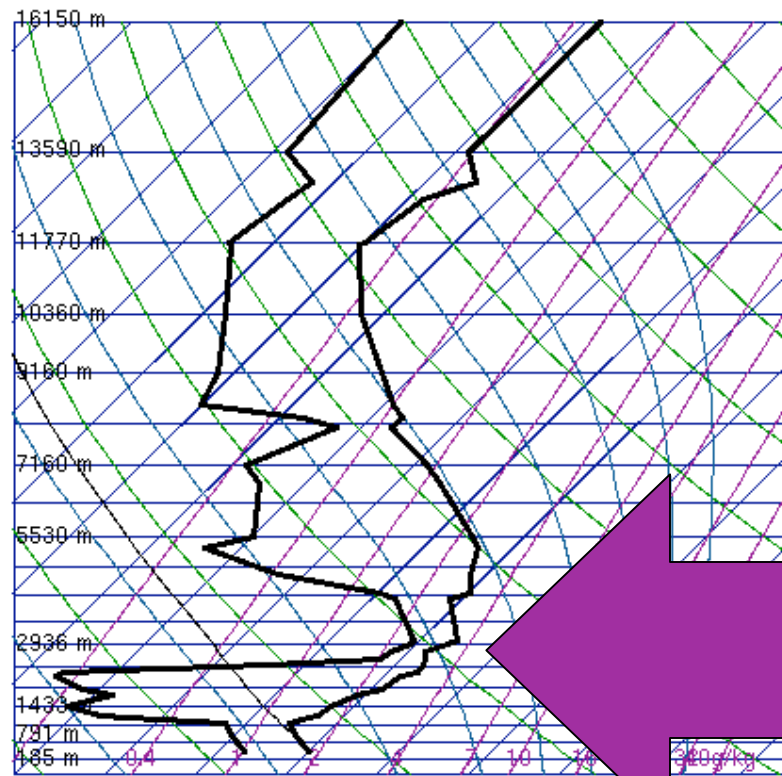
500

600

700

800

900



SLAT 45.45
SLON -98.4
SELV 396.0
SHOW 33.38
LIFT 37.90
LFTV 37.93
SWET 122.0
KINX -42.5
CTOT -25.8
VTOT 3.20
TOTL -22.6
CAPE 0.00
CAPV 0.00
CINS 0.00
CINV 0.00
EQLV -9999
EQTV -9999
LFCT -9999
LECV -9999

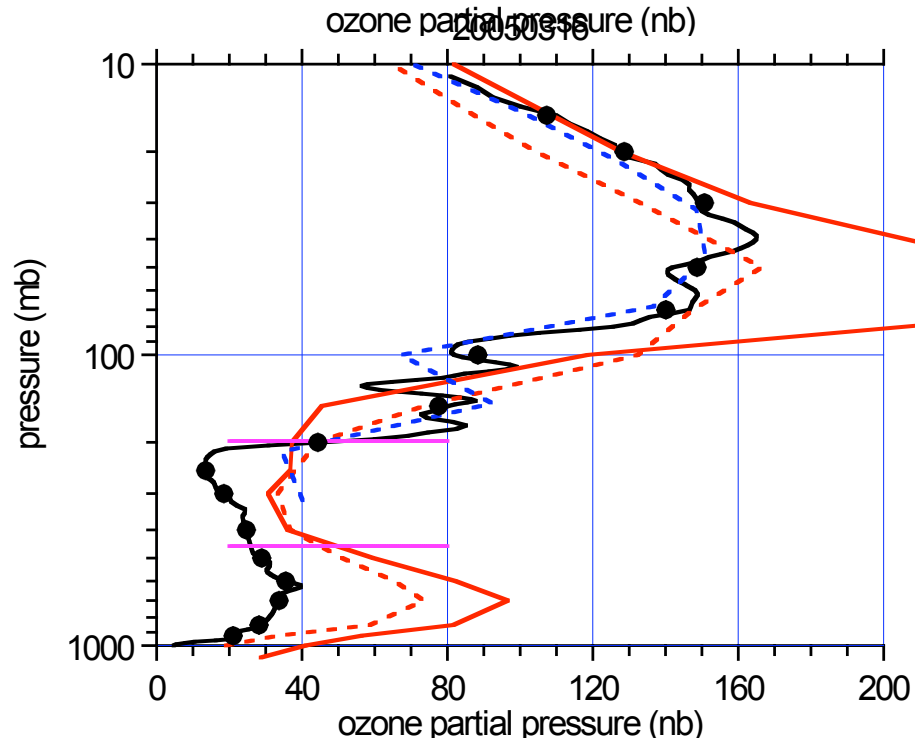
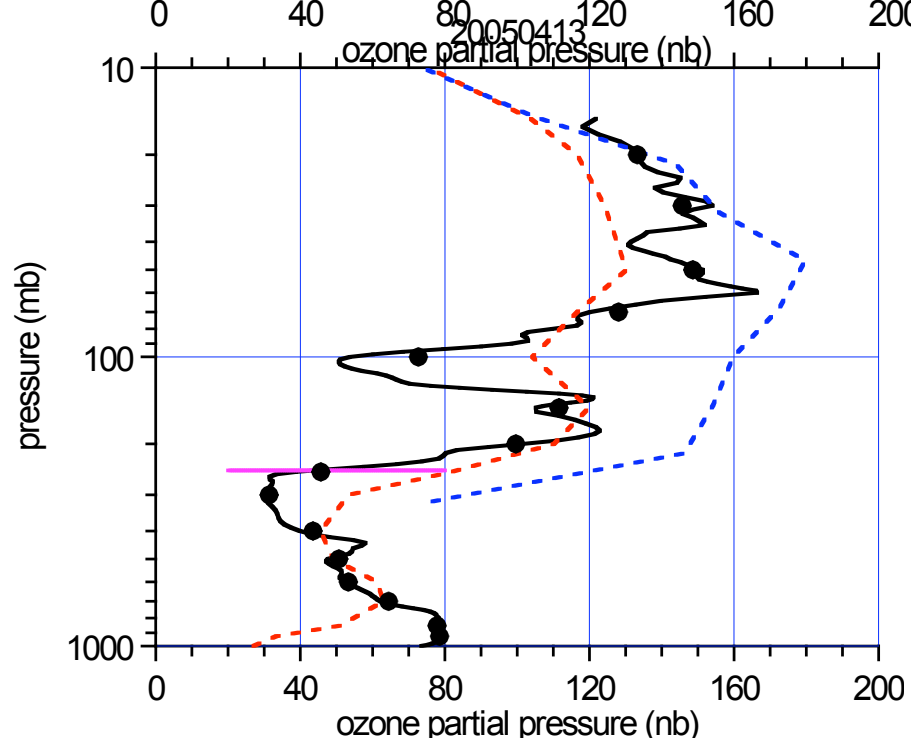
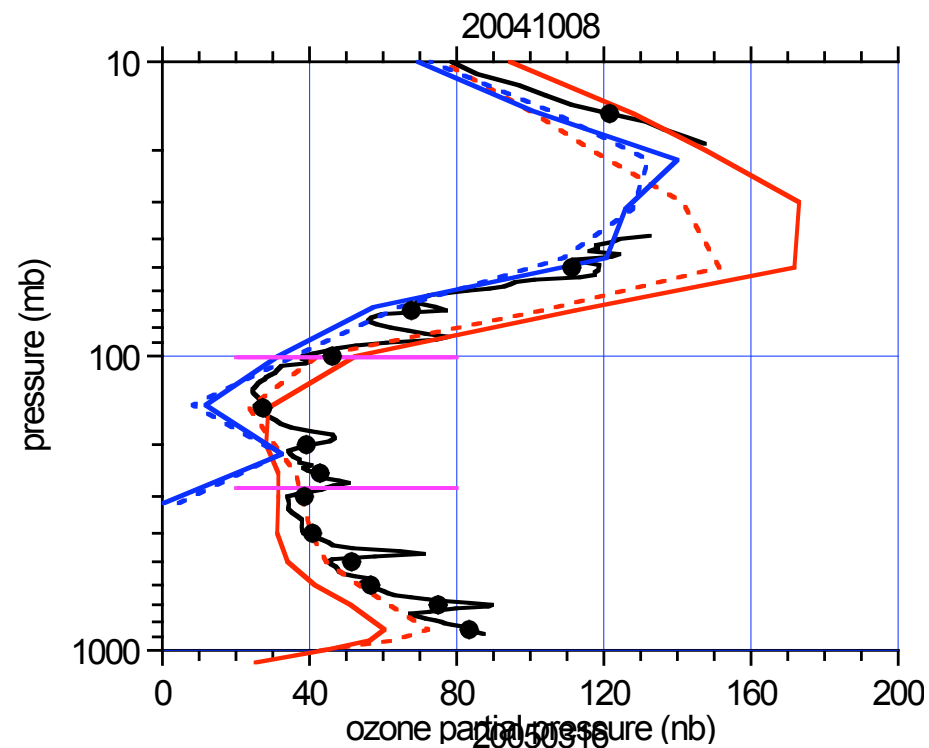
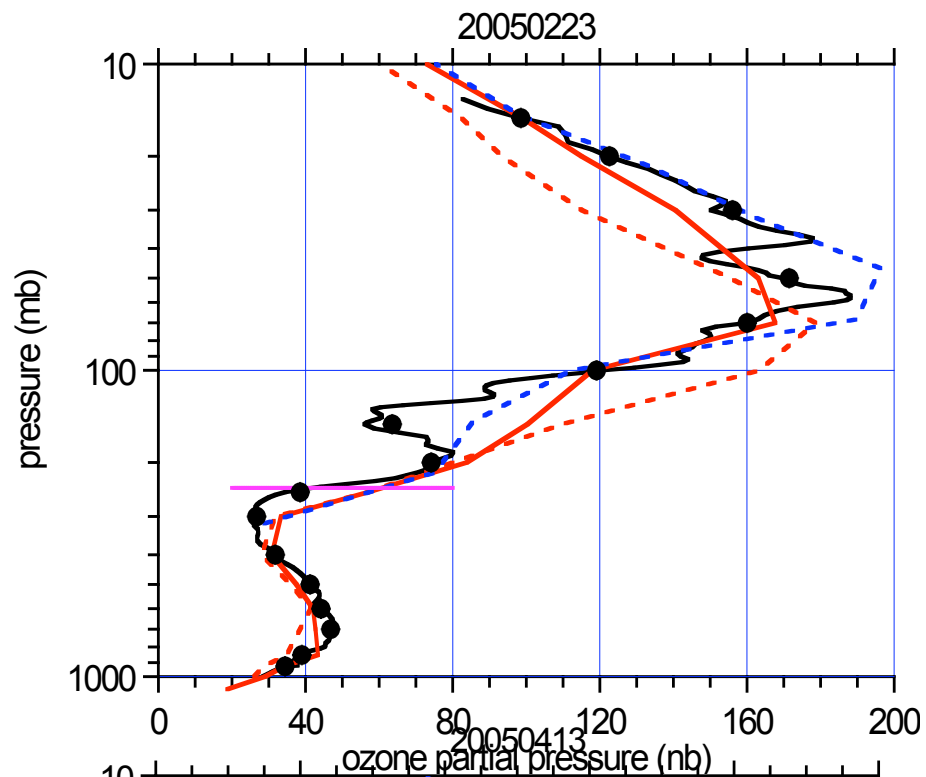
THCK 5345.
PWAT 4.83

12Z 24 Nov 2005

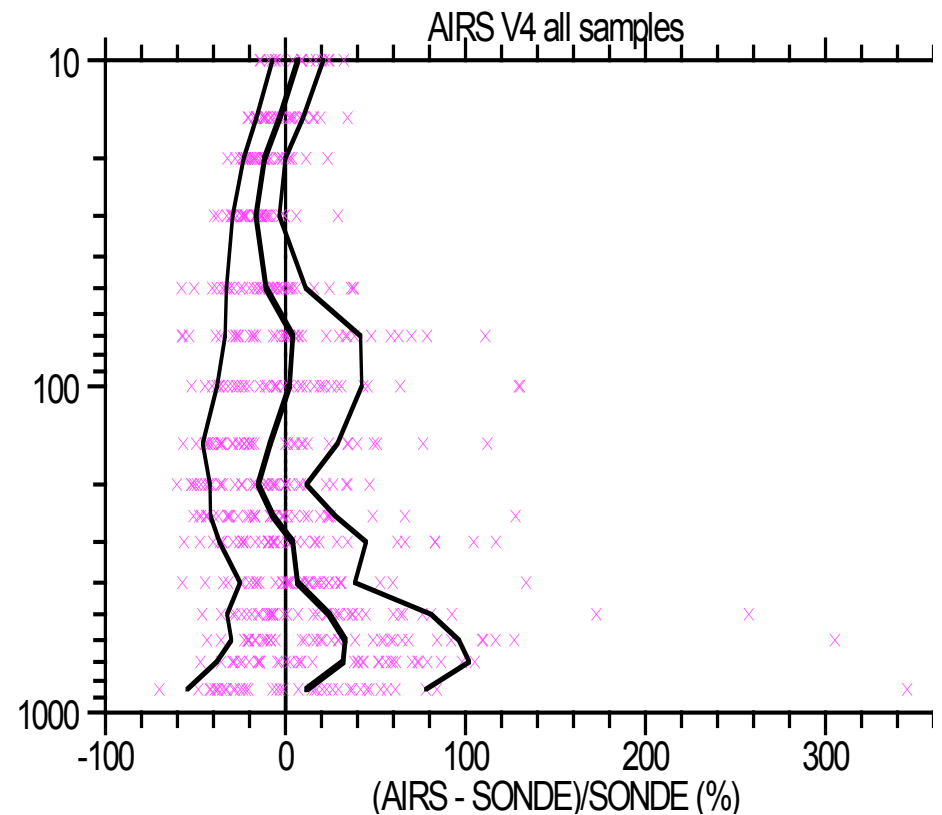
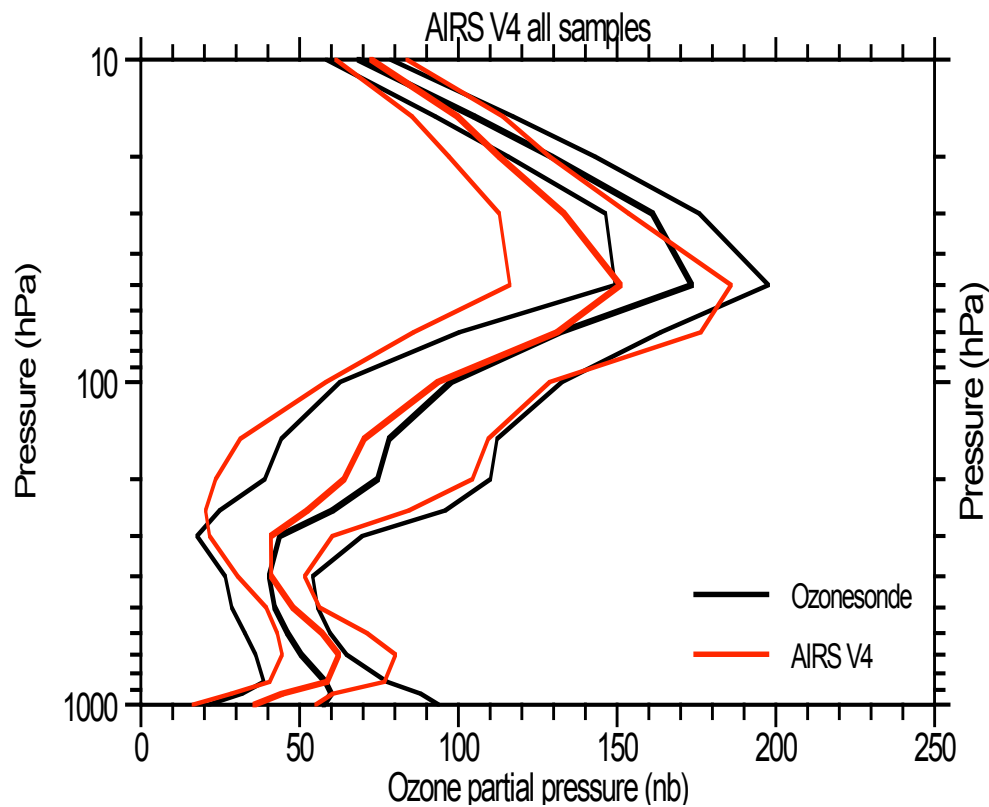
University of Wyoming

Comparisons with ozonesondes over Beijing

- Work of J. Bian and H. Chen (in collaboration with NCAR group)
- Data from Sept 2002 - July 2005, over 70 profiles
- Examples and statistics



Statistics of 70+ Pairs

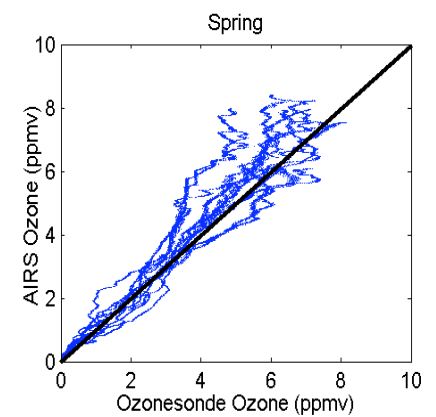
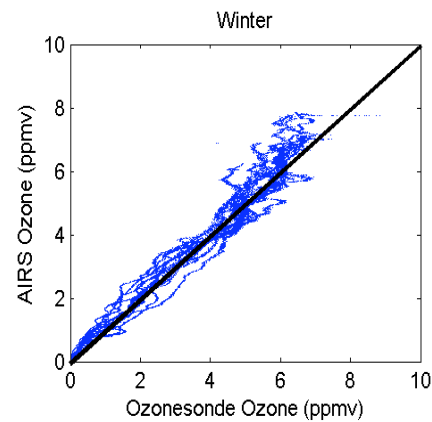
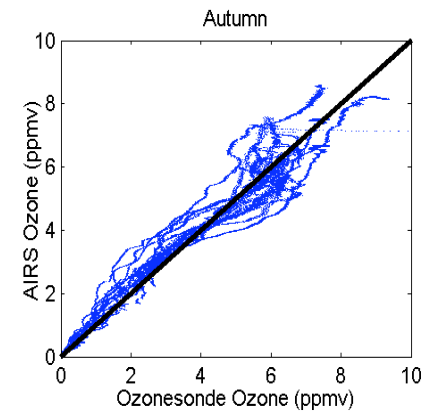
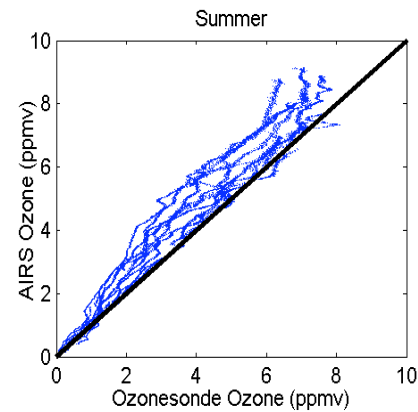
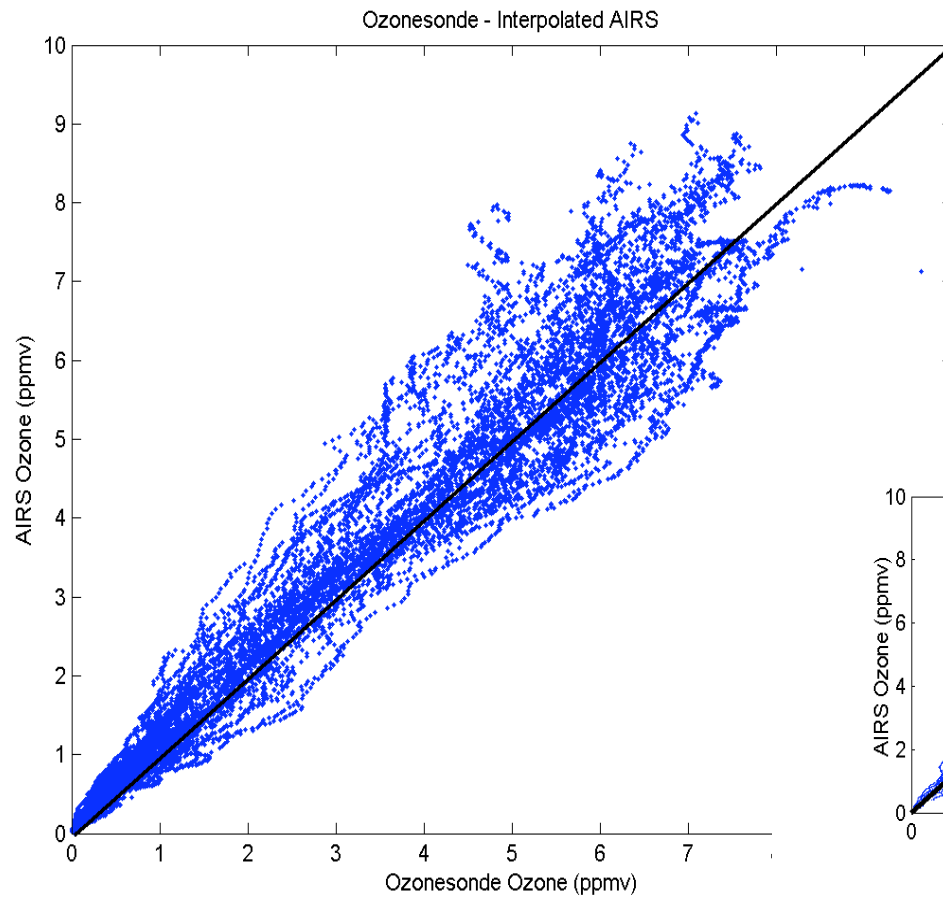


Comparisons with ozonesondes over Lauder

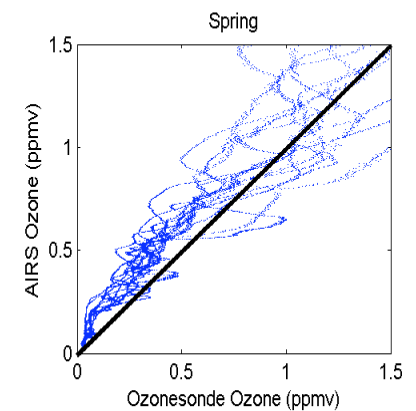
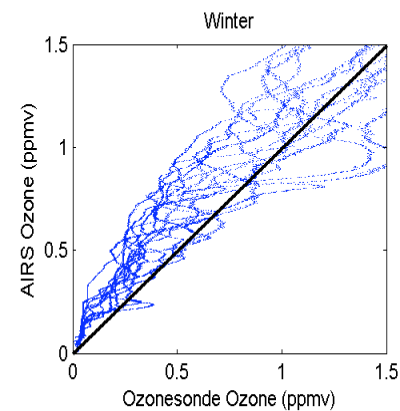
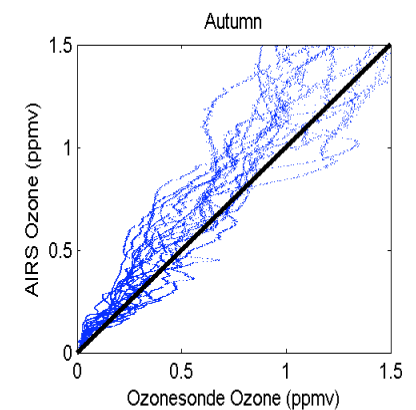
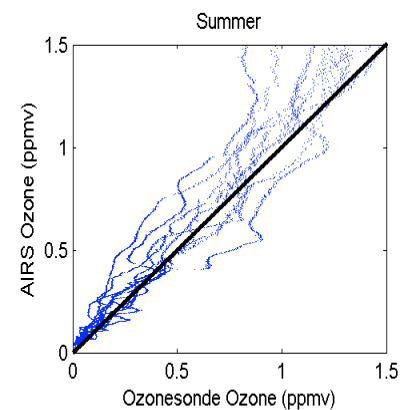
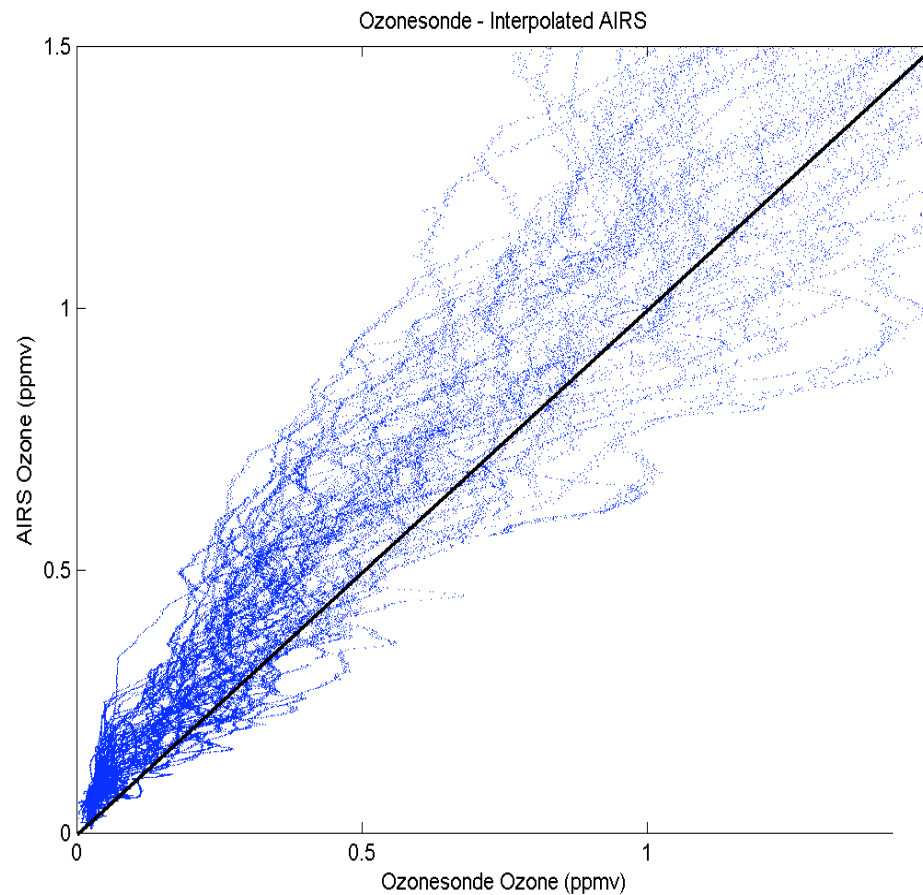
- Work of K. Monahan (Canterbury U. NZ)
- Data from December 2004 - November 2005, 48 profiles

AIRS-Sondes

0-10 ppmv range



0-1.5 ppmv range (UTLS)



Summary of Validation Analyses

- High degree of consistency with dynamical variability of UTLS
- Realistically map chemical transitions between stratosphere and troposphere
-
- Show reasonable agreement with aircraft data over a large dynamical range of ozone
- Initial comparisons with ozonesonde show good agreement between 400–50 hPa range
- Both aircraft and sonde comparisons show AIRS ozone data have a tendency of positive bias in the upper troposphere

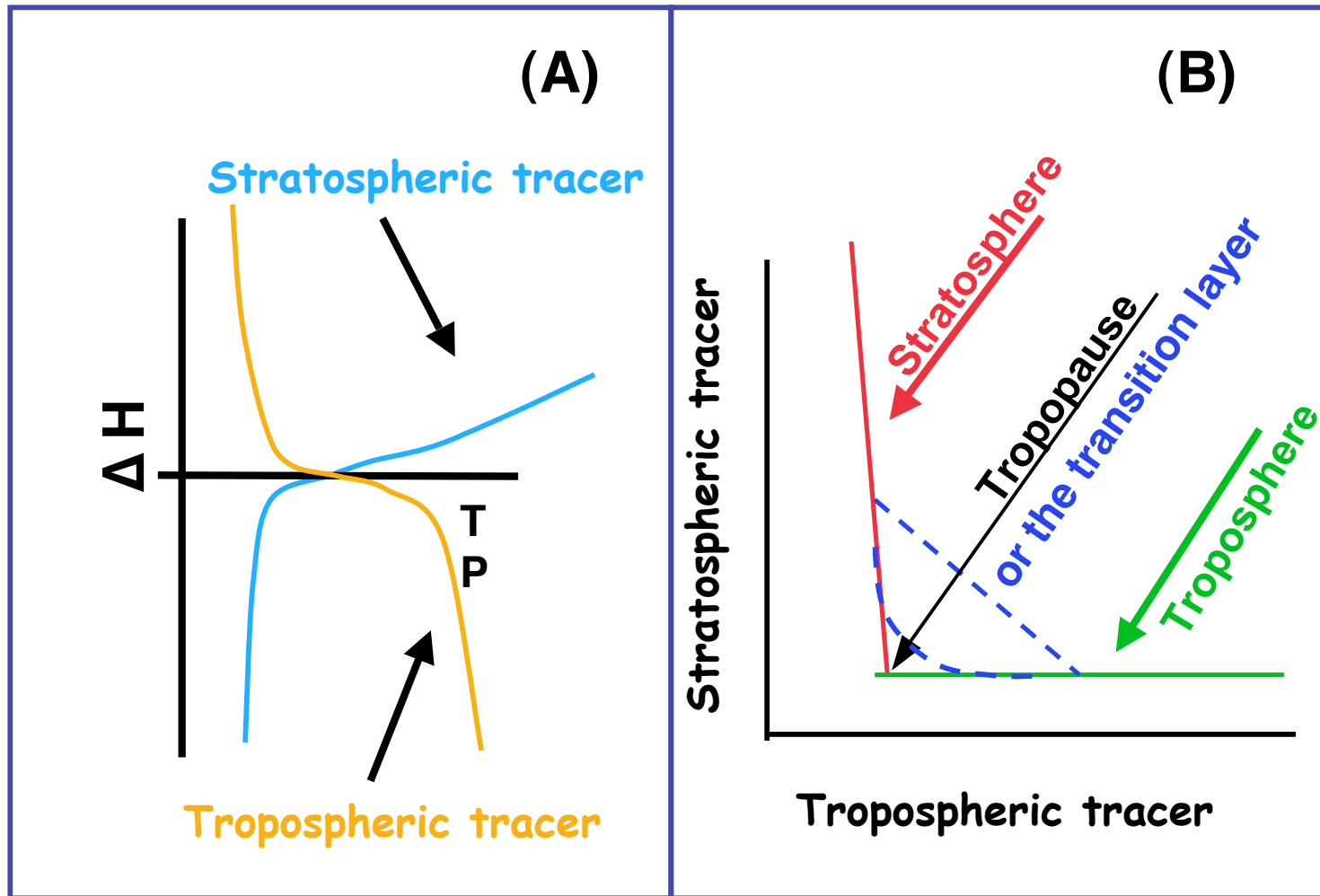
Unique Strength of AIRS Ozone Data

- High spatial density of sampling -> mapping dynamical variability of UTLS chemical distribution
- Good vertical resolution near the tropopause -> dynamical processes control STE
- Ozone and water vapor -> pair of tracers for diagnosing mixing

Diagnosis of STE

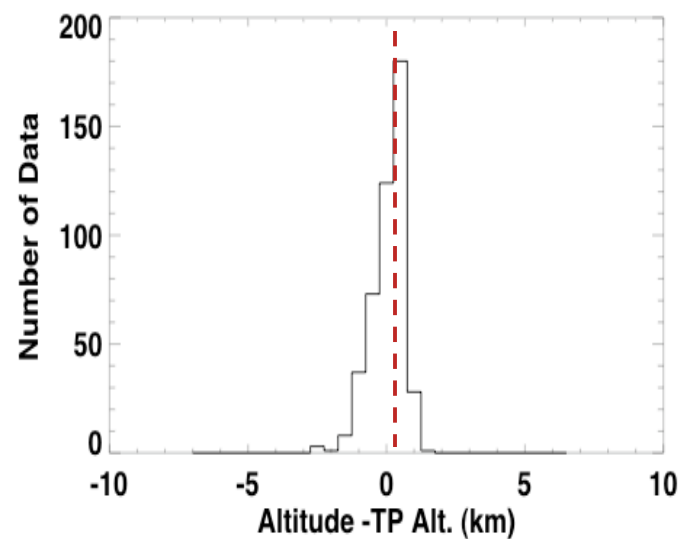
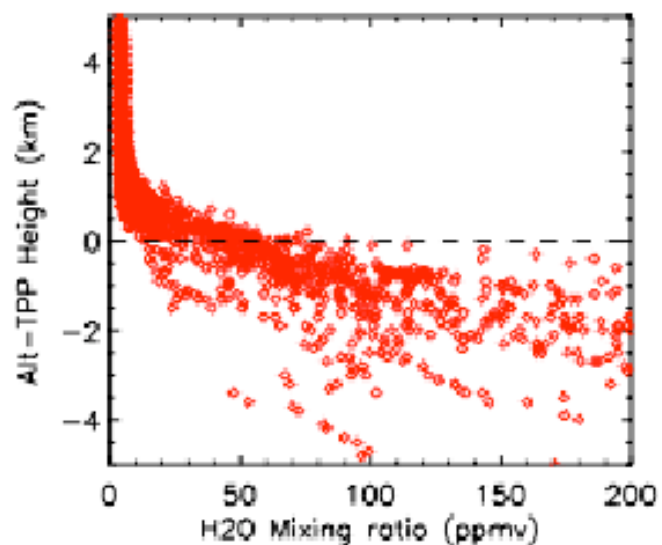
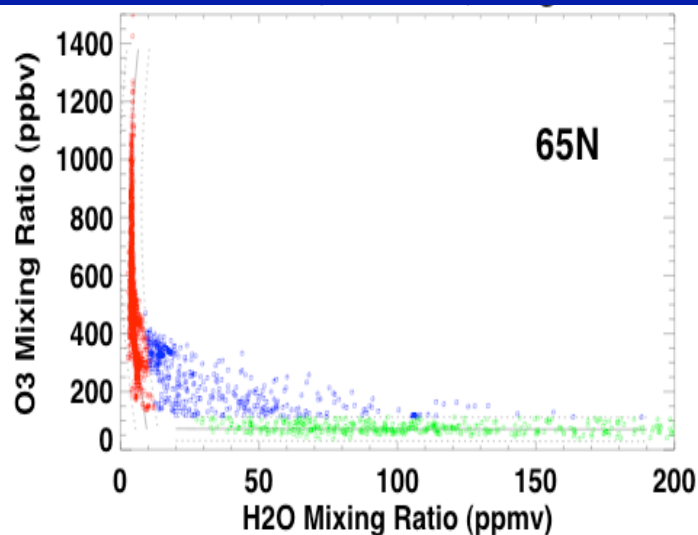
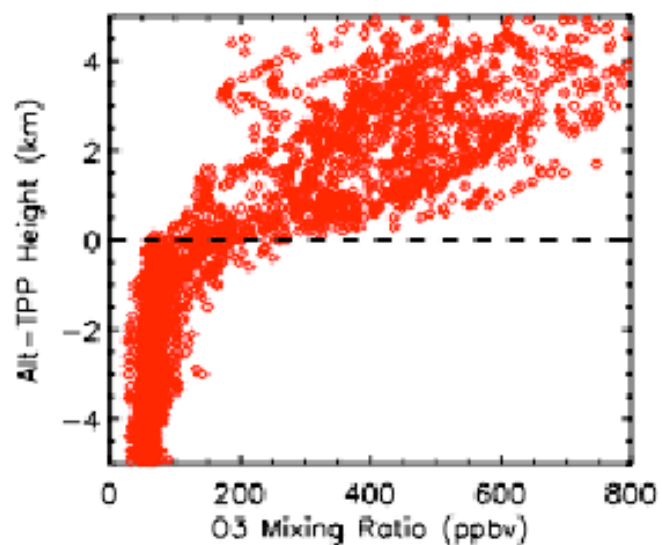
- The use of global satellite (AIRS) ozone and water vapor data for STE studies – where is the preferred mixing location and what controls mixing?
- Chemical transition across the tropopause using tracer–tracer correlations

Chemical Transition from Tracer–Tracer Correlations

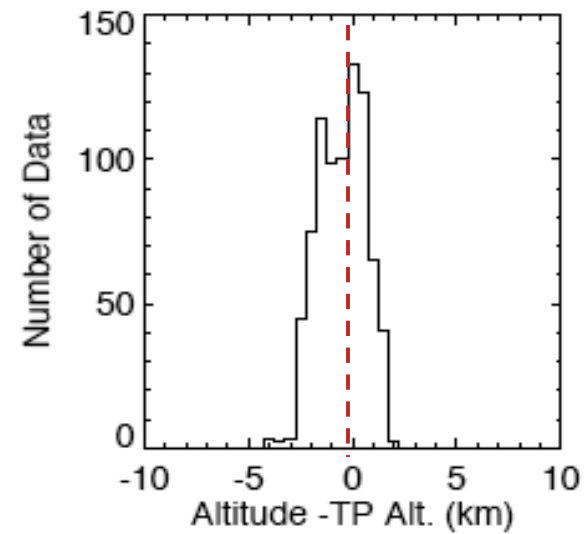
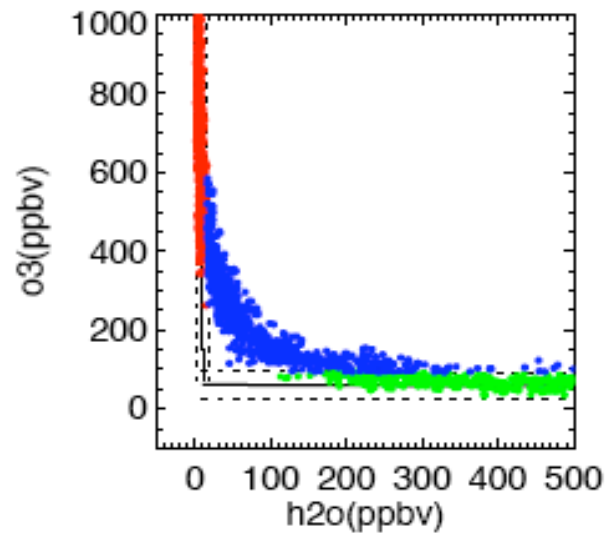
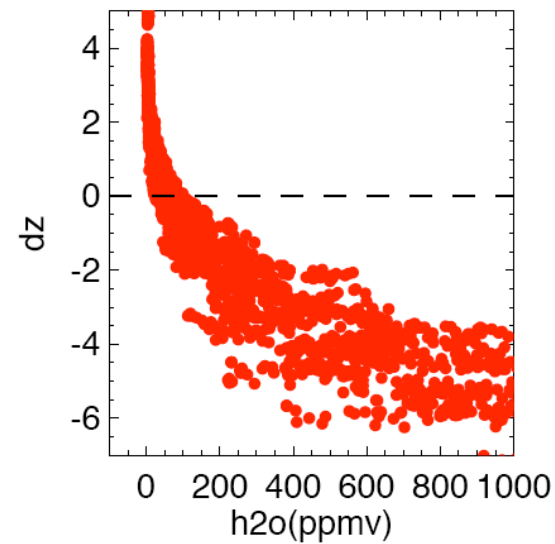
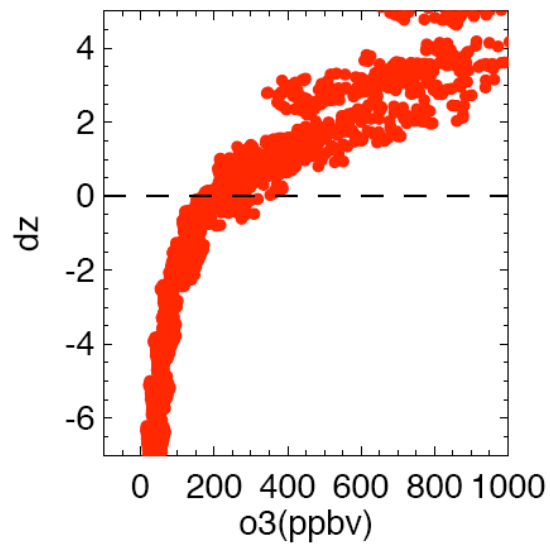


[Pan et al., 2004]

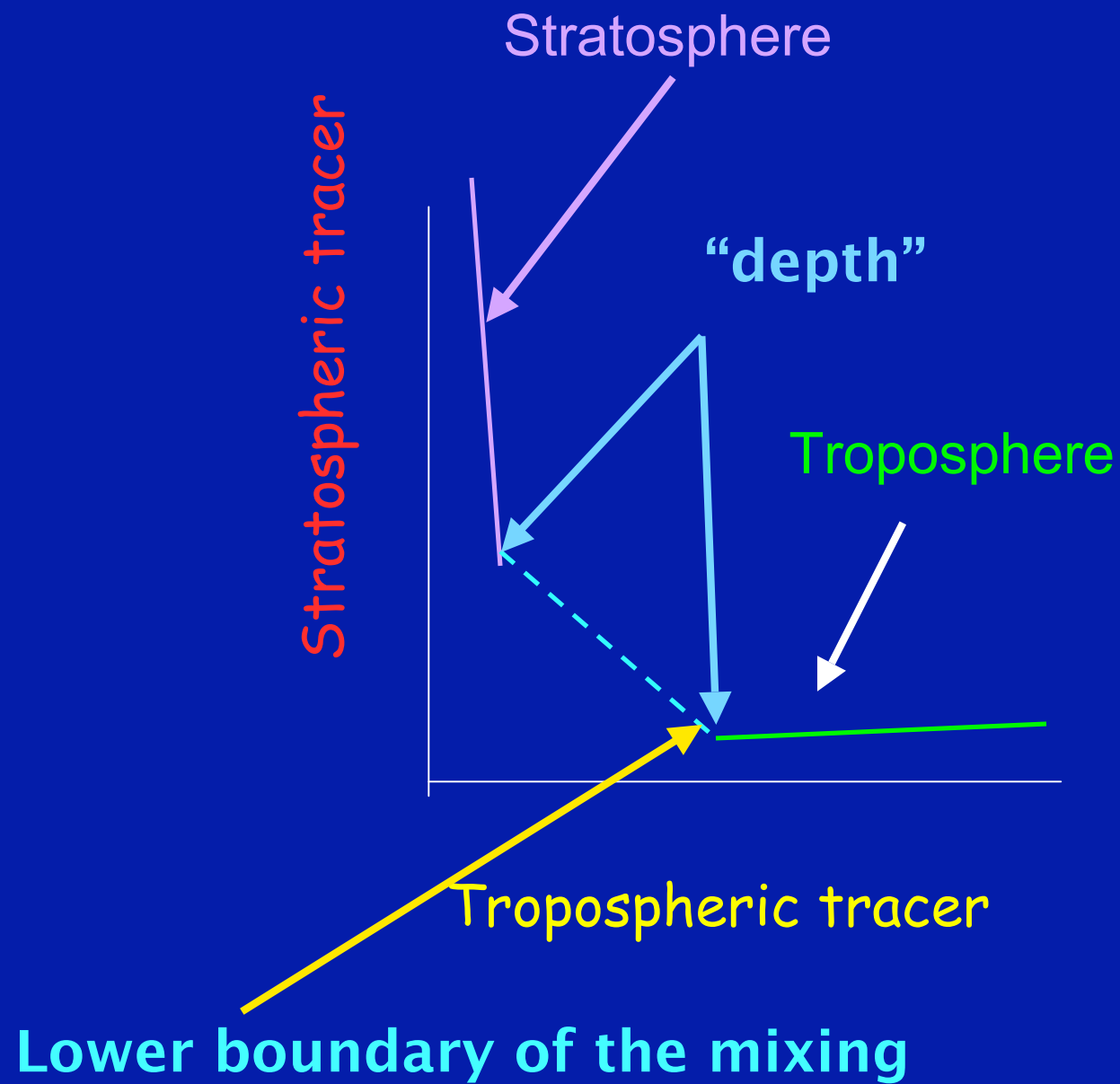
ER-2 data O_3 - H_2O (POLARIS)



AIRS O₃-H₂O May 15, 2004, 65N



**Are these “mixing” points
physically meaningful or
merely the “smearing” of
the retrieval?**

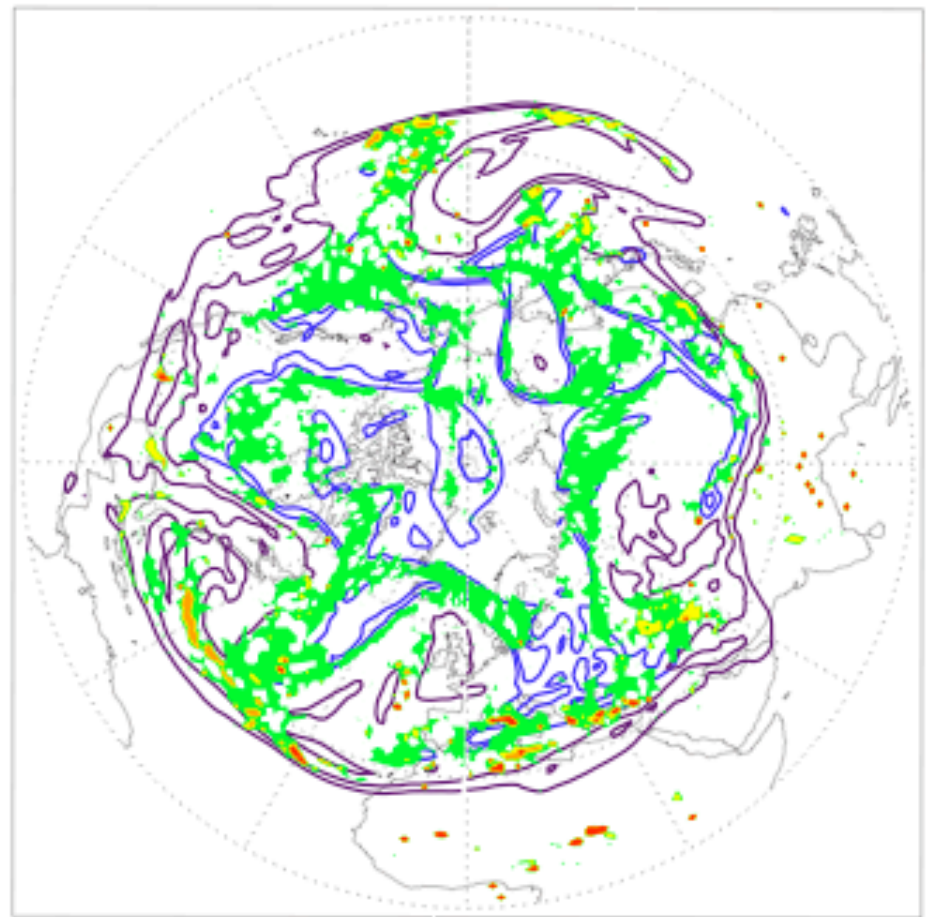
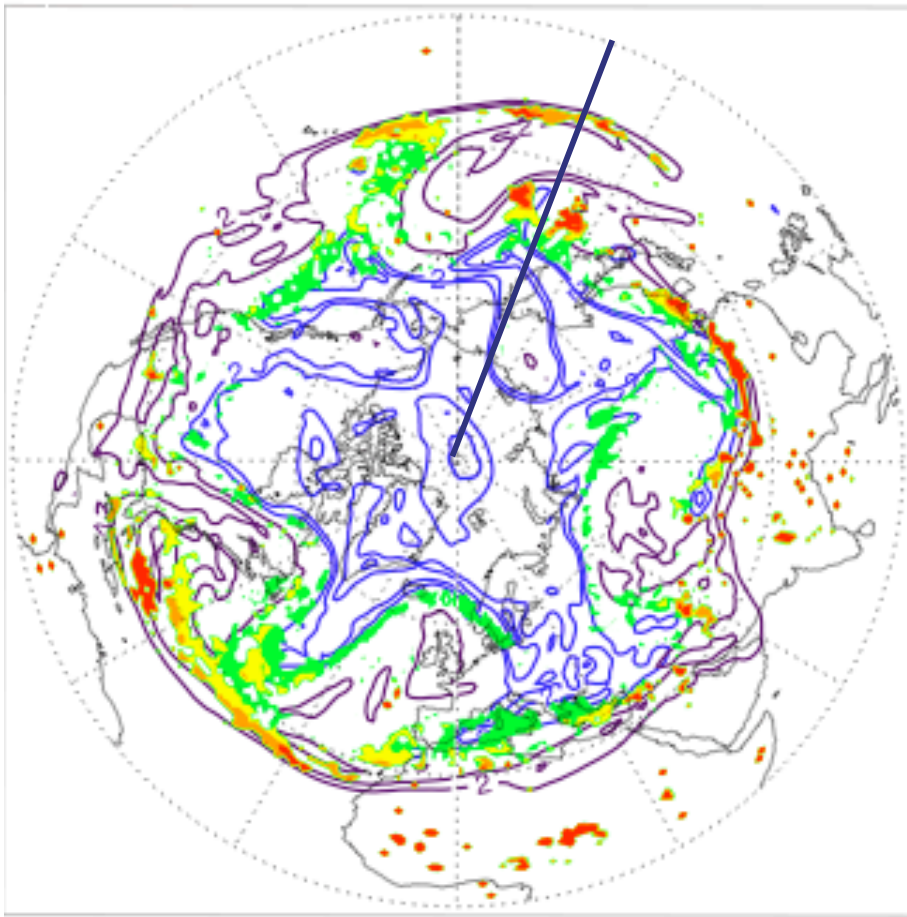


AIRS 20040515, “Deep Mixing”

diagnosis from $\text{O}_3\text{--H}_2\text{O}$

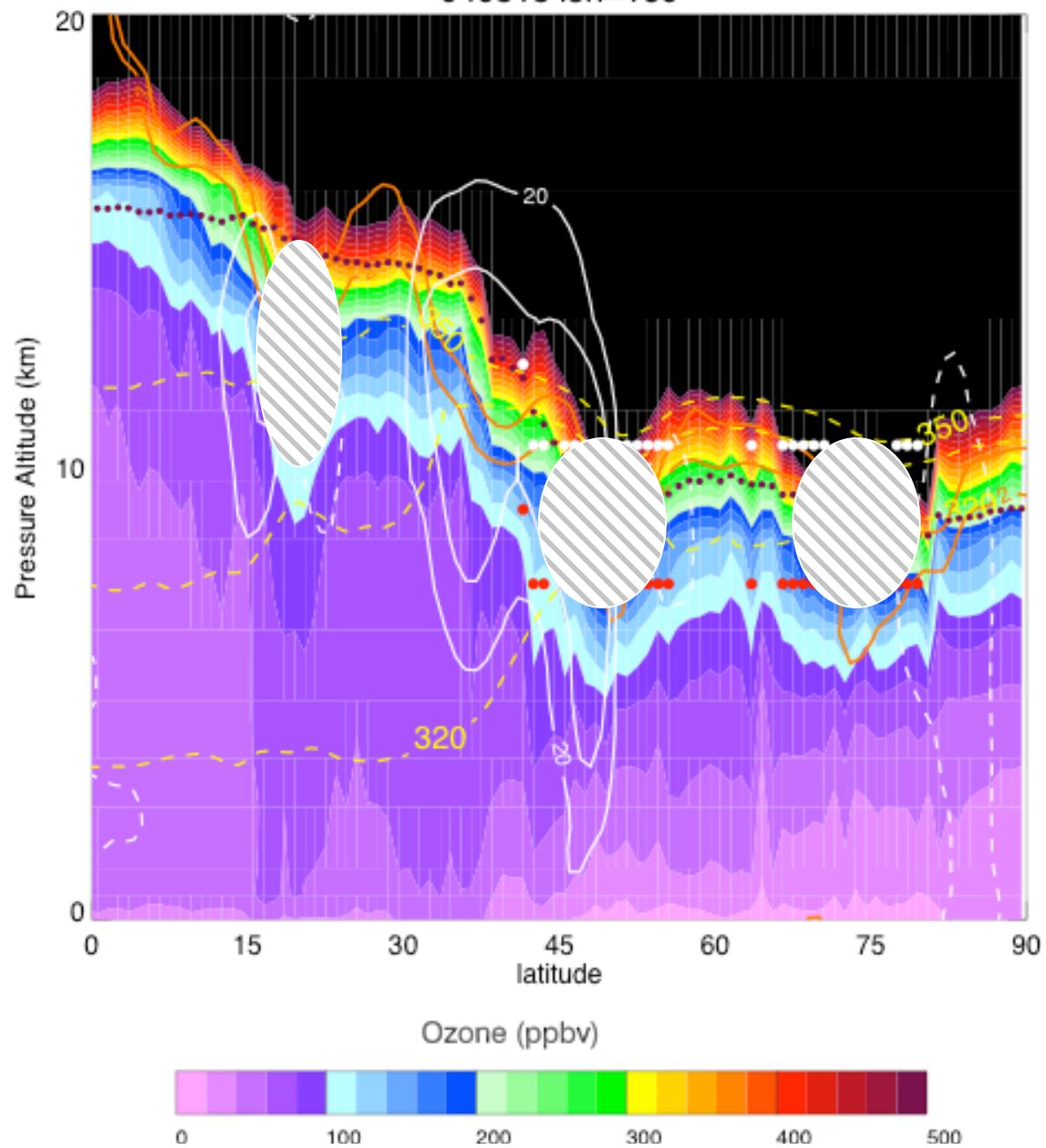
2,3,4,5 km below TP

3,4,5,6 km mixing depth

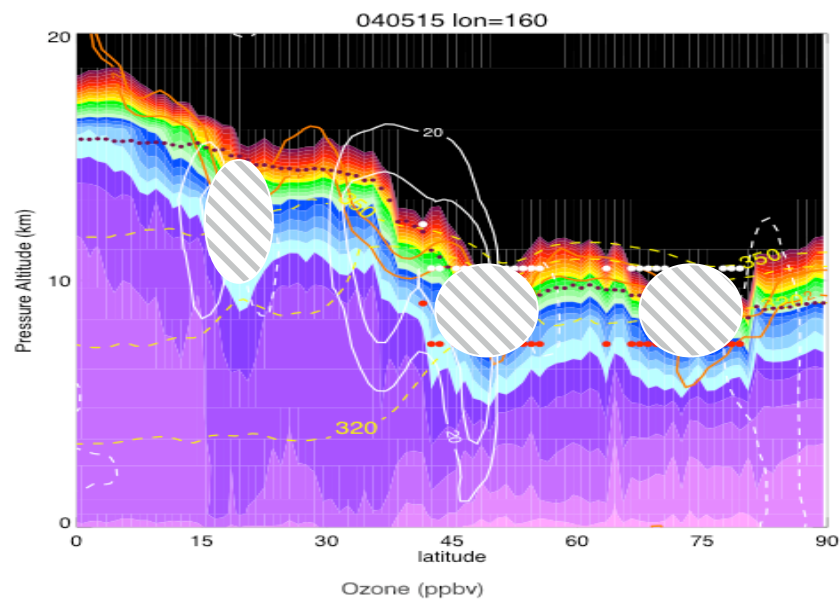
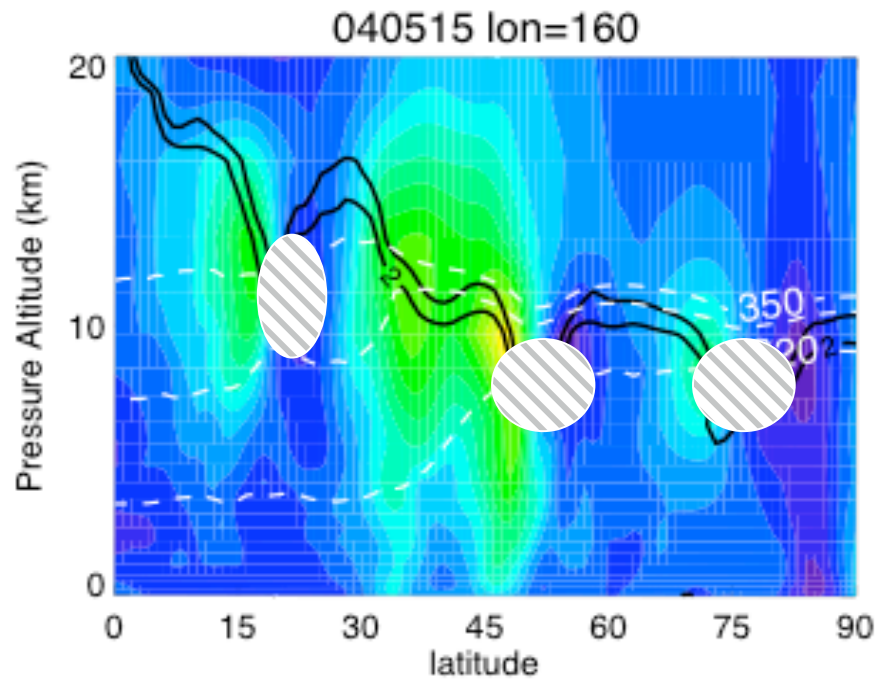


AIRS Ozone 040515

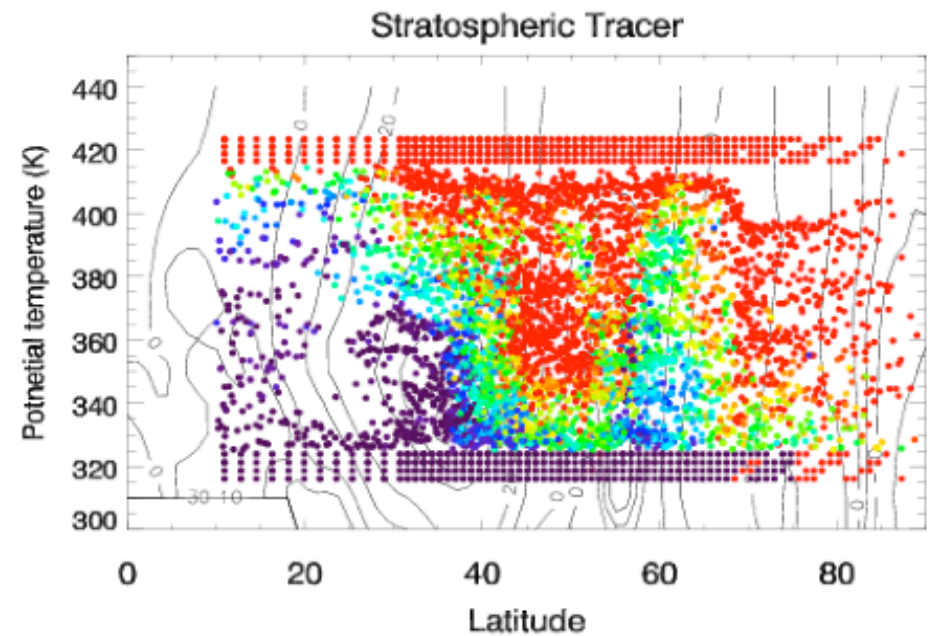
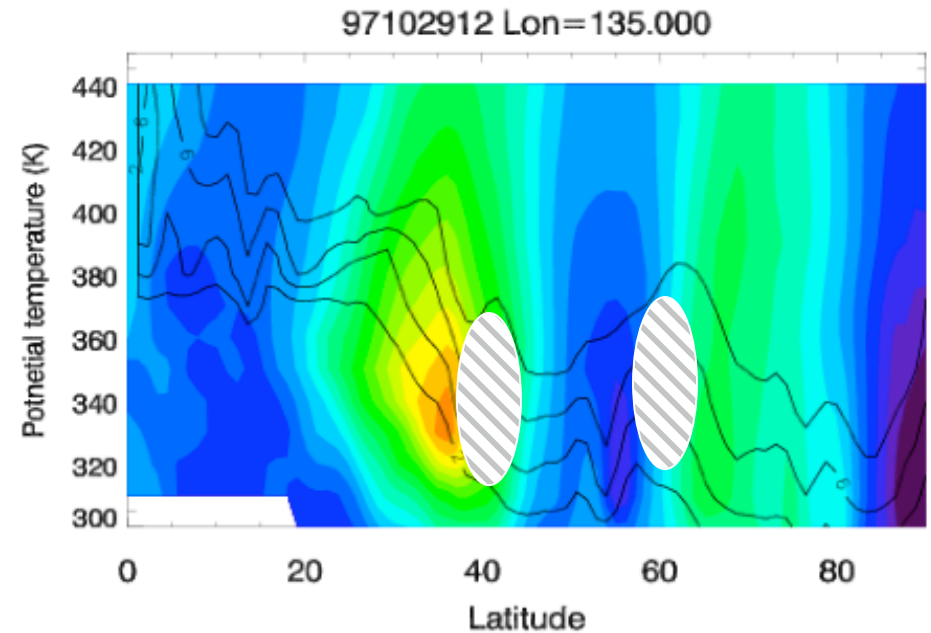
040515 lon=160



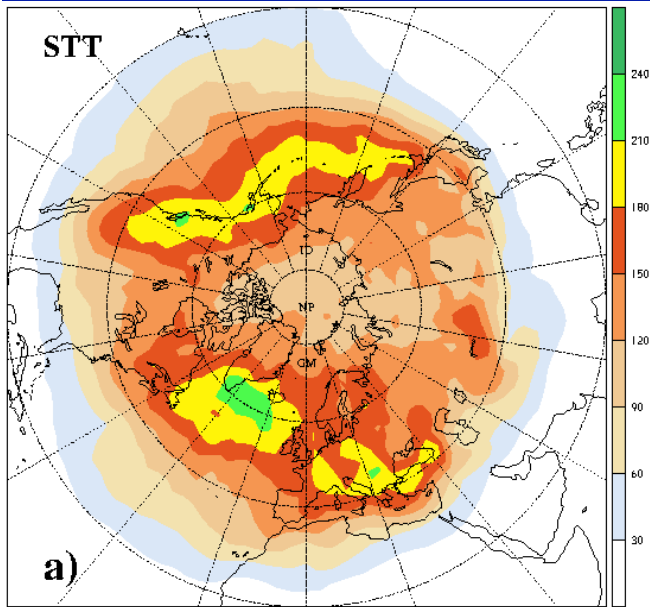
AIRS data analyses



CLaMS simulations

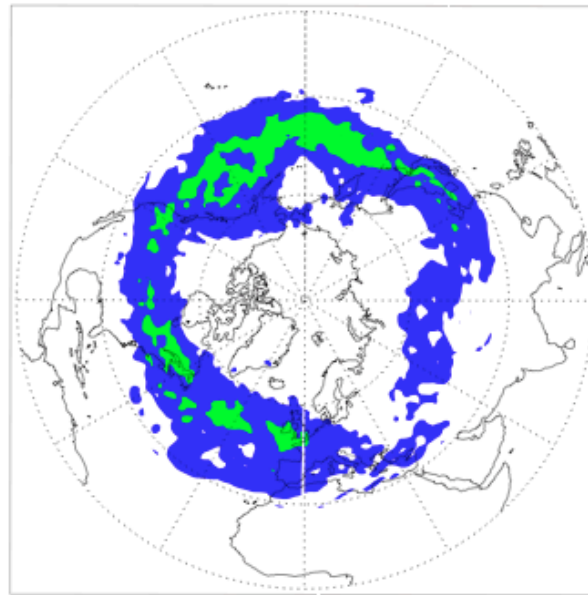


Diagnosing the Preferred Locations of STE Flux



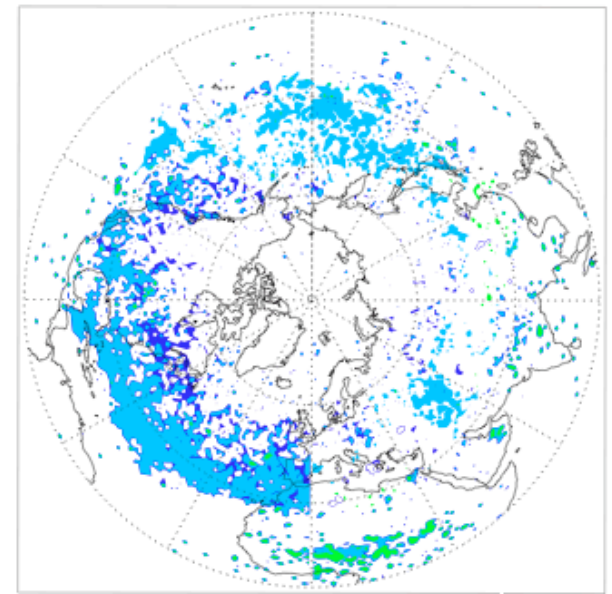
ERA15 clim.

Sprenger and
Wernli 2003 (JGR)



PV “eddies”

200hPa, May 2004



AIRS “Deep Mixing”

May 2004

Work in Progress

- Validation papers in progress using in situ and sondes
- More validation comparisons with GV data
- Chemical transition across the tropopause using tracer-tracer correlations
- Comparisons with CCM's & CTMs

An aerial photograph of Monument Valley, showing the iconic sandstone buttes and mesas. Long, dark shadows are cast across the valley floor, indicating a low sun position. The terrain is rugged and arid, with winding paths visible between the rock formations.

Thank You !

SHADOWS OF MONUMENT VALLEY - FLIGHT 051209